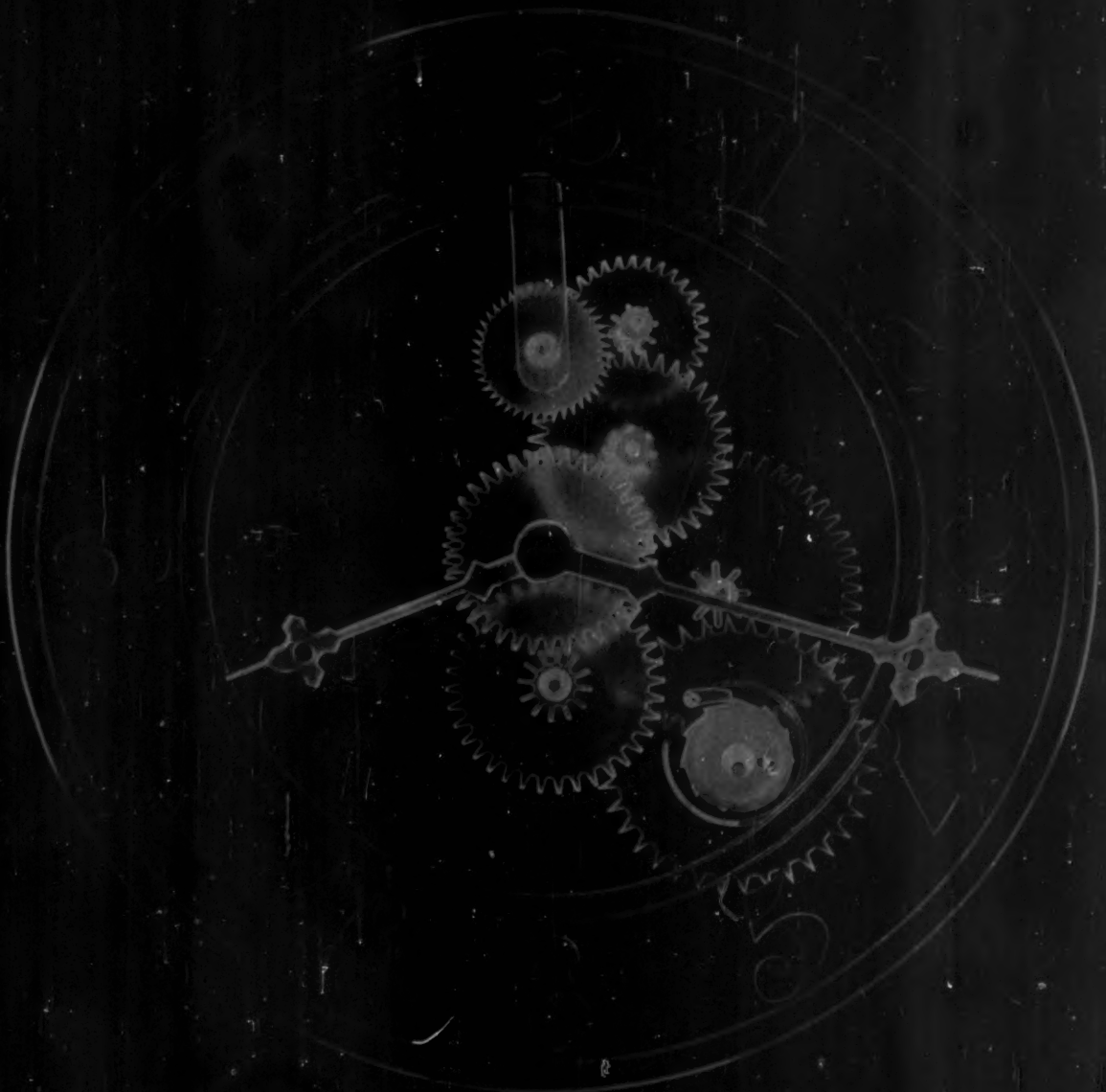
# PRODUCT ENGINEERING

A YEAR

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JULY 11, 1960



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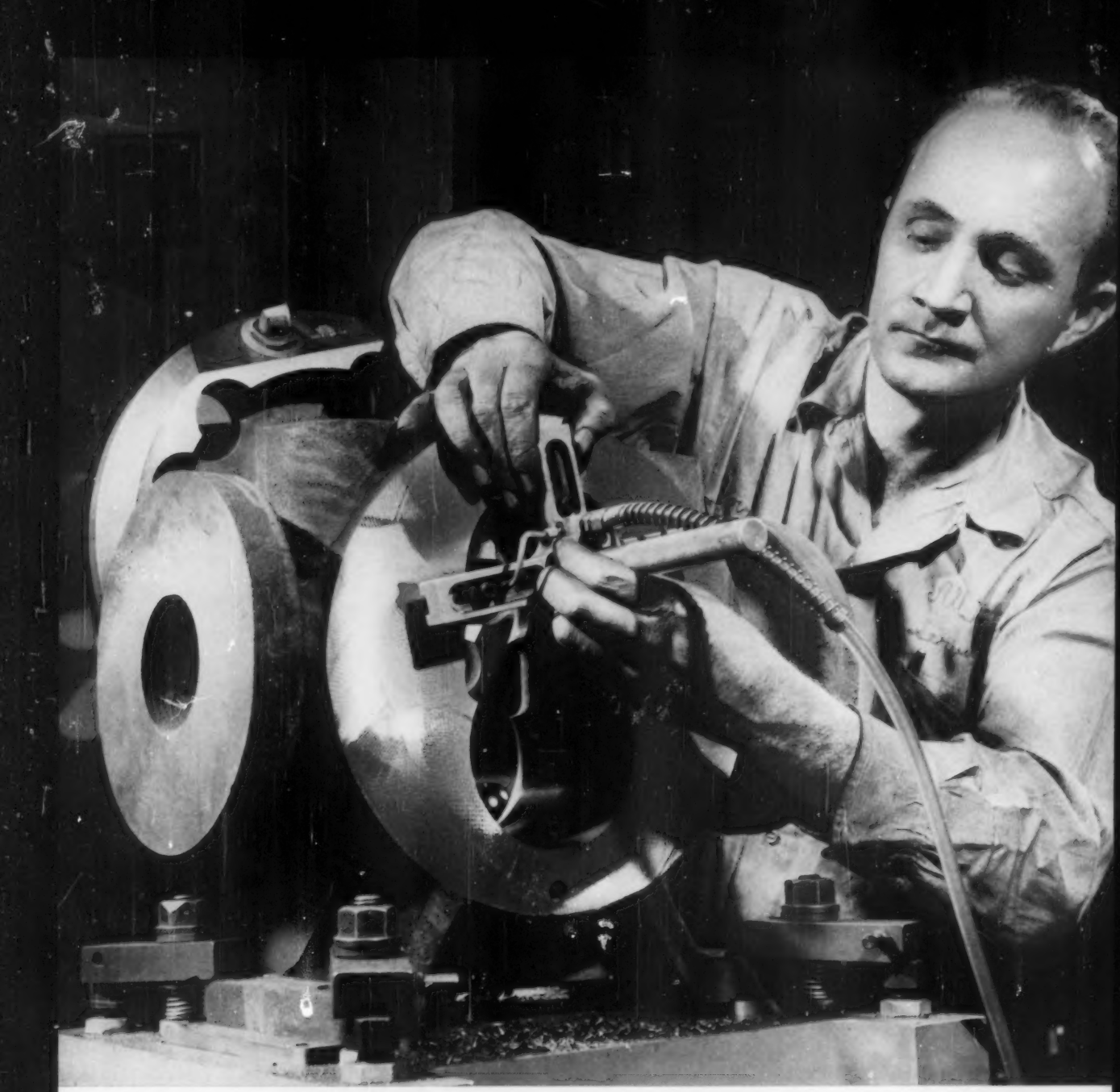

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

July 11, 1960 Vol. 31, No. 28

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**ARMCO STEELS** / for better products • lower costs

# Armco ZINCGRIP Steel Protects Against Rust and Corrosion at Minimum Cost

**Special hot-dip zinc coating that doesn't flake or peel gives formed steel parts economical durability.**

If you are making parts like these—parts that require the strength of steel yet must have low cost protection against rust—Armco ZINCGRIP Steel offers you opportunities to save money and improve product performance. Here's why:

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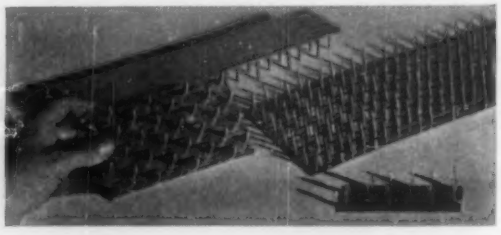
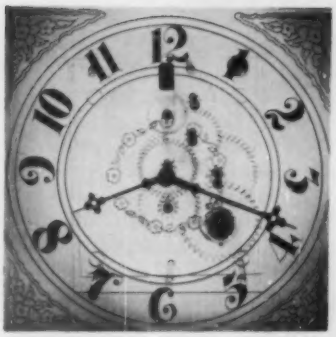


New steels are born at Armco

## ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

# INTERESTING TO NOTE



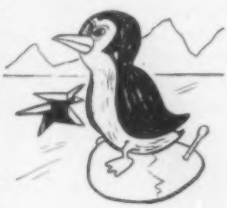
**On our cover**—the gear system for a unique, all-glass clock made by Corning Glass Works to display its photosensitive-glass products. Its gears, hands, clock face—everything but the glass gear shafts were chemically machined. Although the Corning process is a recent development, people have for centuries observed the effects of sunshine's ultraviolet light upon glass. At one point it became fashionable to collect glass that had been turned deep purple by the hot sun of the Southwestern states. In the 1940s, Dr S. Donald Stookey, a physical chemist at Corning Glass Works, became interested in the effects of light upon glass and began a study of photosensitivity.

In time he found that certain glasses, when exposed to ultraviolet light, dissolved much more quickly in acids than unexposed portions of the same kind of glass. This was the beginning of Corning's Fotoform process. Its principal uses have been in the electronics industry, where precise acid-machining makes miniature and complex shapes possible. (See article on page 66.)

With the Fotoform glass still experimental, Dr Stookey decided to make further heat tests. He placed a thin plate of the glass in a laboratory furnace, set the thermostat, and left. Returning several hours later, he noticed the temperature gage read nearly 600 degrees higher than the thermostatic setting. Stookey opened the furnace door, expecting to find a pool of molten glass. Instead he found his test sample intact, but colored dark brown. Then, as he carefully removed the glass plate, it slipped from the tongs, fell to the concrete floor—and bounced with a metallic clang. It had turned into a crystalline, ceramic-like material, and Fotocceram was discovered.

## Egg with Tell-tale Yolk

During the past International Geophysical Year, a group of scientists went to the Antarctic for a series of polar experiments. One study had to do with that region's natives—penguins. Biologists couldn't understand how the penguin could incubate eggs in temperatures as low as −77 F. Did they actually keep the eggs warm, or could the eggs hatch at comparatively low temperatures? A team of embryologists, zoologists and physicists set out to develop a method of investigation. Since full cooperation from the penguins could not be ensured, scientists had to find other ways to take periodic temperature readings of the eggs. To complicate matters further, the penguin sometimes ambles around with its eggs cradled between its instep and stomach.



However, a nest could be found—and robbed. Coloring

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an egg with green paint for identification was also no problem; but designing a thermometer into an egg presented a few headaches.

First, an egg was stolen from an Adelie penguin and bisected. Next, a tiny, elliptical, transistorized transmitter was placed inside the eggshell, which was then resealed with cement. Enough liquid was added through a small hole to equal the weight of a normal egg. This "bugged" egg, calibrated against a standard thermometer, was then returned to the nest, and the penguin accepted it without question. For 132 hours, the radio worked perfectly, transmitting its own temperature at 15-minute intervals. It showed that despite the frigid surroundings, the penguin maintained an average temperature of 92.7 F in the egg.

For the story of a different kind of thermal actuation, see p 74.

**Fresh Fish, Two Rocks a Pound**

Money, the search to find it and the desire to spend it, has caused trouble throughout history. Today, companies keep such a keen eye on spending that a new discipline, Value Engineering (p 61), has been conceived to squeeze a product's manufacturing cost to the lowest possible figure.

Money is as old as man, but it hasn't always taken the form of the familiar silver disks of today. Probably the coinage of money began in Greece around 700 BC. A natural amber-colored material, electrum, is thought to have been the first substance employed for coins. Later, the Greeks used alloys of silver and gold, while the Romans used bronze. Those early coins were but one means of barter. Perhaps the strangest money system is the one still used by the inhabitants of the Palau Islands in the Pacific. Since the islands have no metal, and shells are too common, they decided that the stablest form of currency would be a type of stone quarried from another island group 200 miles away. A round, flat stone about a foot in diameter is worth about fifty cents. A huge millstone 12 feet in diameter is worth about a thousand dollars.

Obviously, these gigantic rocks couldn't be toted to the market place every time the housewife wanted to buy a fish for dinner, so the islanders have worked out an amazing system of credit. If you gain title to a rock in exchange for goods or services, you don't have to cart away the burdensome coin. Both parties simply make a mental note of the rock's new owner (there is no written language). If your money happens to rest on another man's property, you have the right to visit it any time you desire. Evidently the islanders have had good memories, because no serious arguments over ownership have been reported. —Benedict A. Leerburger Jr

## SIDELIGHT

It came in too late to mention in our article on "You and Your Employer" (*PE—June 20, p 59*). But we're hoping it may be a new straw in the wind. Raymond Atchley Inc, a subsidiary of American Brake Shoe, just announced a 6120-sq-ft expansion of its plant near Los Angeles. The new space has been made into 35 air-conditioned mahogany-paneled private offices for design engineers. This averages 175 sq ft per office or the equivalent of about 12 x 15 ft of working room per man. The new quarters are to encourage creative thinking, where the men "may grow to their own capabilities."

## NEXT WEEK IN PRODUCT ENGINEERING

. . . **Electron Beam Welds in Vacuum**

What you can weld with high-velocity electrons and how to put this process to work.

. . . **The Lagging Pace of US Invention**

President of the Sloan-Kettering Institute tells why we're not the great technical inventors we seem to think.

. . . **Buckling Conditions of Coil Springs**

Latest equations for predicting what happens when a coil spring is compressed between parallel or nonparallel plates.

. . . **How to Select Miniature Lamps**

When space won't allow a standard lamp—6 watts or larger—you may have to turn to the little fellows.

. . . **Polyamide-cured Epoxy Resin**

What you should know about this important model-shop material.

. . . **Is Today's Engineering Education Giving Us Creative Engineers?**

A young engineer gives his point of view.

In this 1960 LEWYT Vacuum Cleaner, Flexible Tubing does two important jobs: (1) it carries dirt, (2) it conducts electricity

# Proof that today's designers can make Flexible Tubing do almost anything

In the new Lewyt Vacuum Cleaner, Model 121, a motorized head revolves brushes that beat out and sweep up the dirt. How to get power to this Motorized Beater Sweeper — without unsightly wiring — posed a problem.

Solution: Flexible Tubing's "Vac-U-Flex" vinyl hose. It carries the dirt — and conducts the current through a unique double-coil wire reinforcement *inside* the hose wall. Neat . . . simple . . . efficient — and styled to match the machine. Perfect example of the design versatility you get with Flexible Tubing!

Whenever the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product that can do the job! You can choose fabrics, coatings and sizes to fit your specifications.

Flexible Tubing is at work today in diesel engines, electronic computers, farm combines, television transmitters and hundreds of other places. To find out what Flexible Tubing can do for you, just mail the coupon.

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**Gentlemen:**

I'm designing a new product ☐ I'm redesigning an old one ☐ One of my problems is the handling of air ☐ liquids ☐ light solids ☐ Could be Flexible Tubing can help me solve them. I'll give you 10 minutes to show me, to prove it. Phone for appointment ☐ No problems right now. Send me literature for my files ☐

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# DEVELOPMENTS TO WATCH...

## Ceramic relays move another step ahead

First reports on the ceramic (piezoelectric) relays being developed by Clevite Corp (*PE—Jan 11, p 8*) indicate that such devices are feasible and can operate over a rather wide temperature range. Prototype models have already been applied to snap-action switches; and other drive applications may be explored.

"A full evaluation has not yet been effected," says Clevite; "but preliminary tests indicate operating speeds of less than 5 millisec are obtainable."

Release times for the ceramic relays are a function of the shunt load resistance; this, in turn, influences the sensitivity. Where the duty cycle is small, shunt load impedances in excess of 1 megohm can be used, with a resulting sensitivity of less than 10 milliwatts for 100-v operation and 2.5 milliw at 50 v. If release times lower than 100 millisec were required, though, impedance loads of about 100,000 ohms would be needed.

Clevite emphasizes that little is known as yet about shock and vibration resistance, for instance. But progress thus far is decidedly encouraging.

## Heat resistance of electronic components boosted

Printed electrodes that stand temperatures above 2300 F, and thin-film resistor, conductor, and capacitor elements that will operate continuously at nearly 1400 F, are reported by Mellon Institute.

Produced by both evaporation and screen-printing techniques, the samples include glaze and nonglaze types. In general, the nonglaze, produced by screen printing, show considerably higher heat resistance than the samples made by vacuum evaporation methods. Research is continuing, under Air Force sponsorship.

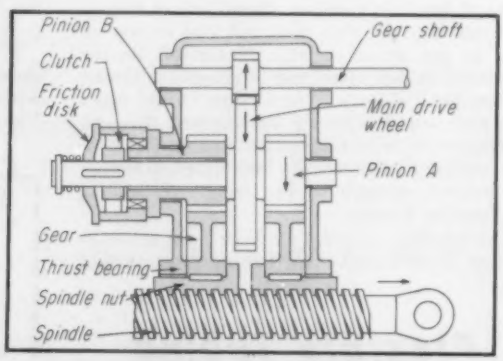
## Transmissionless engine sought by Army engineers

An engine that will deliver power directly to a vehicle's wheels—without requiring a complex transmission—is the ultimate aim of a research program now underway at Detroit Arsenal. Arsenal engineers admit they're still a long way from that goal. But they have made substantial progress in developing "responsive" engines—engines that will deliver exactly the combination of torque and speed required at any given level of performance. Latest designs are more than halfway towards that goal, and further progress is expected. No reports have been issued as yet on this "responsive engine" research; but full disclosure is expected within the next year.

## Austrian engineer designs no-backlash drive

To prevent spindle rotation in an extension beam drive, Felix Fritsch of Simmering Graz Pauker, AG, Vienna, has devised the dual-nut system diagramed here.

In the new spindle drive, there are two separate nuts, one driven directly, the other through a freewheeling friction-type clutch. The latter is adjustable from outside the spindle gear housing. Thus it is possible to preselect the pressure between the two spindle nuts, assuring, says SGP, close fit without backlash. —ARG




**AUSTRIAN DRIVE** features twin nuts, one driven directly (by gear), the other through a free-wheeling clutch. In the unit diagramed, pinion *A* is directly driven; pinion *B* is driven through the clutch.

# Have you ever attended a Lamb Electric MOTOR CONFERENCE?

If you are planning a new product that will require a Special Fractional Horsepower motor . . . a Lamb District Engineer will set up a "Personalized Motor Conference", just for you.
Result: The RIGHT MOTOR produced at the most favorable cost.

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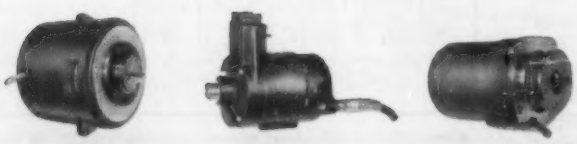

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SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

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## More-stable lubricants coming up

The best way to prevent lead corrosion by diester oils in storage is to exclude moisture, says Naval Research Lab's Chemistry Div. But, where that is impossible, new additives show promise of minimizing the problem.

Lead corrosion results from the progressive formation of an acid half ester by progressive hydrolysis. This is catalyzed by acid phosphates, among them, tricresyl phosphate used as a wear-inhibitor. But, they say, aliphatic amines can effectively neutralize the phosphates, largely eliminating the problem. An interim report (NRL 5451) is being prepared and will be available in photostat and microfilm form from OTS, Dept of Commerce, Washington 25, DC as PB 144526.

## Europe leads US in application of new materials, engineer claims

The Europeans are about two years ahead of us in use of thermoplastics for automobiles, W. P. Gobeille of American Motors told an SPI meeting; and, he says, they're achieving savings in weight and operating economy that we can't match.

Among the new applications that will bring increased usage are hoods, wheel disks, fan blades, fuel tanks, interior window moldings, complete molded seats.

## Columbium alloy shows resistance to heat, corrosion

The 80-10-10 columbium-titanium-molybdenum alloy developed by DuPont and Thompson Ramo Woolridge, is now reported to be "conservatively 5 times as resistant to oxidation as pure columbium, and about 100 times as resistant as molybdenum." Ductility at room temperature and resistance to thermal shock are also reported to be good. Tensile strength at room temperature is 100,000 psi, and even at 2000 F in air, it is 34,500 psi.

DuPont says the alloy (D-31) can now be produced in sheets 0.020 to 0.100 in. thick in widths to 24 in., bars 3/4 to 3 in. dia, and foil 0.005 by 6 in.

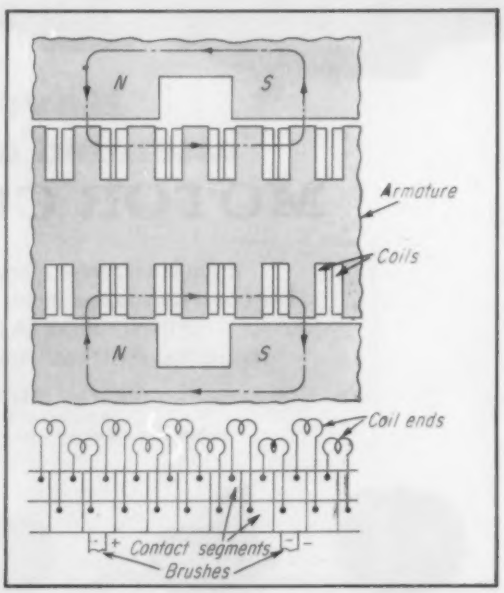
## British have new motor with two speed ranges

A linear motor that will provide both power-traverse and micro-inching speeds is claimed by AIE (Rugby) Ltd of London.

The armature winding is made up of a number of winding sections, each is connected to terminal contacts on the armature, with means provided for connecting them selectively in series, parallel, or series-parallel. This may be done by providing alternative contact strips that are selectively brought into engagement; or by use of a rotating drum carrying a series of shaped contacts positioned so they can be brought into engagement in the desired order.

In the prototype model, the winding sections are in the form of annular coils, seated in circumferential grooves around an iron core mounted integral with the operating shaft. The windings are connected to adjacent segments of two linear or rotary commutators, and brushes positioned around one provide current.

The commutators are linked with the armature shaft in such a way that they transfer excitation current from the windings directly in the stationery field to those about to enter it. —ARG




**ARMATURE** of linear motor, moving axially in magnetic field, carries paired winding coils, as indicated in upper diagram. Lower diagram shows how coil ends connect to commutator sections and brushes.

# WHAT'S HAPPENING IN RESEARCH . . .

## *Fuel cells: sidelights on design*

Now that the operating principles and potential advantages of the fuel cell have been widely demonstrated, auxiliary problems like storage and regeneration of fuels are coming into the limelight.

At a meeting of the Society of Aeronautical Weight Engineers, for instance, C. K. McBaine of North American Aviation, pointed out that four systems might be used for storage of hydrogen and oxygen: high pressure, ultralow temperature, submersion of cold compressed hydrogen gas in liquid oxygen, and storage of hydrogen in chemically combined form (hydrides), with liberation of the element as needed.

There are at least four methods available, too, for regeneration of the reactants in this system: electrolysis, photolysis (including biological action), radiolysis, and thermal decomposition.

Which will be the best choice? The final answer will, of course, depend on the application. But before any final answers can be supplied, McBaine believes a lot more attention is needed to classification and conduction of the criteria used for judging fuel cell systems. His suggestion, not surprisingly: classification and analysis is the basis of over-all system weight.

## *Antimony and cobalt strengthen titanium*

Titanium-antimony alloys are stronger and harder than unalloyed titanium, Bureau of Mines researchers report. Antimony, in amounts to 10%, increases tensile strength 30 to 100%. Furthermore, for equivalent hardness and tensile strength, the antimony alloys show a higher yield strength than unalloyed titanium without sacrificing ductility. In a 5%-Sb alloy, for instance, at 150 Bhn, the increase in yield strength is on the order of 10%.

Bureau researchers have also been testing the effect of cobalt on titanium-vanadium alloys and report cobalt is considerably more effective in strengthening titanium than is an equal weight-percentage of vanadium. Ti-V alloys, even with vanadium in amounts to 16% by weight, show a tensile strength no greater than 122,000 psi. Addition of cobalt—even a mere 2%—raises the figure to 127,000; and 4% brings it close to 138,000. Surprisingly, an 8%-V alloy, with cobalt additions, developed even greater strength. The basic alloy showed a strength of 107,500 psi. With 2% Co, it jumped to 134,800; and 4% Co brought it to 167,500 psi. Hardness, too, reached a peak in the 8%-V alloys, with both 12% and 16%-V materials showing somewhat lower hardnesses, though not as low as the 4%-V.

## *Choosing glass for vacuum systems*

Aluminosilicate glassware is superior to most other types when pressures range down toward $10^{-10}$ mm Hg, says W. W. Campbell Jr of Naval Research Lab.

Tests at NRL indicate potash soda lead glass can't stand the high bake temperature often required to produce such vacuums. Borosilicate glasses and high-silica glasses have relatively high helium permeation constants.

But new aluminosilicate glasses not only stand bake temperatures to 1200 F (annealing point is above 1300 F); but also can be sealed to molybdenum and have low permeation constants. Linear coefficient of expansion is 42 times $10^{-7}$.

## *briefs . . .*

**Strain gages must be compensated** for radiation, just as they are for temperature, say N. J. Rendler and R. C. Smith of Naval Research Lab. Studies of the effects of nuclear radiation on ceramic-bonded strain gages indicate their electrical resistance varies with reactor power, and there are both temporary and permanent damage effects. But, they say, when instrumentation can be designed for a dry, noncorrosive atmosphere, and insulation resistance can be monitored, it is possible to compensate for these changes so that such gages will operate satisfactorily as transducers in a radiation environment.

**Impact strength** of mild steel at low temperatures can be increased by minor additions of columbium, says British Iron and Steel Research Assn. Alloys having 0.8% Cb are reported to show "a general displacement of the transition curve, dropping the Charpy V-notch transition temperature to minus 94 F." On the other hand, though columbium is known to increase room-temperature yield point and ultimate tensile strength, BISRA says it does not, in small percentages at least, seem to increase the elongation.

**Chromium alloy "fabrics"** are the best materials now available for reentry parachutes, says Arthur D Little Inc in a report prepared for Wright Air Development Div. ADL evaluated a wide range of metal, ceramic, glass, and polymer fibers and fabrics; it found several high-melting glasses, refractory metal alloys, and single-crystal "fibers" worth further investigation. But, says ADL, fine wire fabrics made from nickel-chromium and cobalt-chromium alloys are the best bet right now. Copies of the report (PB 161411, 166 pages, $3) may be obtained from OTS, Dept of Commerce, Washington 25, DC. —ARG

**OSCILLOSCOPE CAMERA,** hinged to permit easy access to shutter and lens, has binocular viewer, Polaroid film pack, mounts on standard scopes. Analab Instrument Corp, Cedar Grove, N J supplies it with a choice of three lenses. Price range: $405 to $445.

*On the 1960 Westinghouse Laundromat...*

# NEOPRENE AND HYPALON® ELIMINATE OZONE-CRACKING: ARE SPECIFIED FOR ALL RESILIENT COMPONENTS

In designing their new Laundromat automatic washer, Westinghouse engineers set out to solve an aggravating problem: ozone deterioration of rubber parts. They knew from experience that drain hose, gaskets, boots and seals made from ordinary rubbers were susceptible to the oxidizing effects of ozone, and they wanted to eliminate this danger in their new design.

Needed were synthetic rubbers capable of performing dependably despite exposure to ozone, heat, abrasion, detergent water and bleach. The solution was provided by a pair of rugged Du Pont elastomers: neoprene and HYPALON.

Neoprene was chosen for its exceptional ability to absorb punishment. Unusually resistant to ozone, this versatile rubber is also highly resistant to heat, abrasion, oils and chemicals. And neoprene's excellent age resistance *keeps* appliances on the job. Neoprene parts stay tough and lively, without cracking, swelling or softening.

HYPALON is *completely* impervious to ozone, whether atmospheric or motor-generated. Ideal for seals, hoses, and other molded or extruded parts, it resists deterioration and stays resilient despite constant abrasion, flexing, temperature extremes.

To learn more about the Du Pont elastomers, and how these synthetic rubbers can solve *your* appliance design problems, write for our fact-filled booklet outlining properties, performance and applications. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department PE-7, Wilmington 98, Delaware.

**Ozone tests like this convinced Westinghouse** — Specimen on left, made of natural rubber, has deteriorated completely after only 14 minutes of ozone exposure. One on right, made of HYPALON, is unaffected after 100 hours of exposure to the same concentration of ozone.

DU PONT
REG. U. S. PAT. OFF.

**SYNTHETIC RUBBER**
NEOPRENE HYPALON® VITON® ADIPRENE®

**Better Things for Better Living . . . *through Chemistry***

# NEW...

## with capacities to 50 hp!

## LINK-BELT

# RS P.I.V.

### VARIABLE SPEED DRIVES

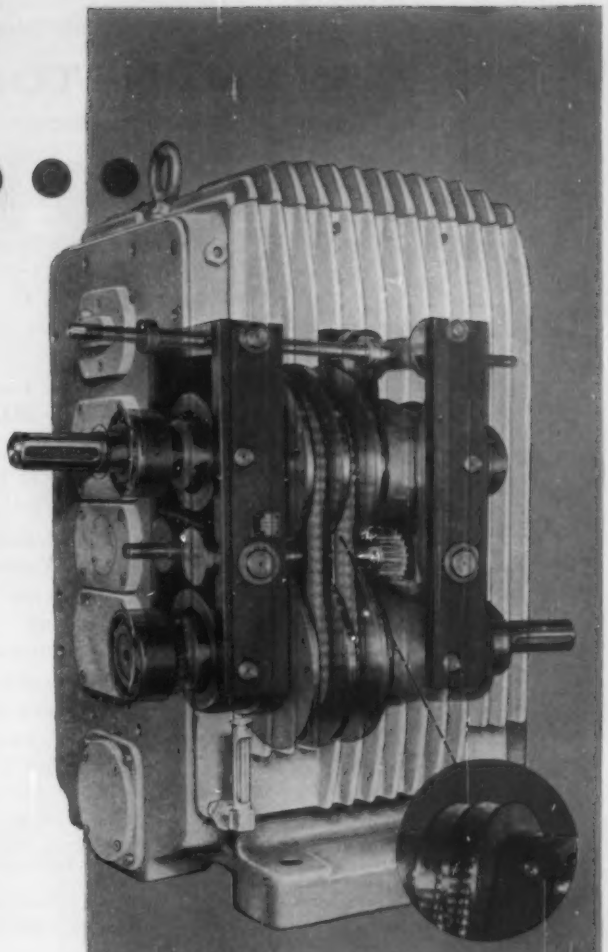
***All-metal drives use single-roll chains to achieve positive, stepless, infinitely variable speed control***

With a unique chain design and force lever system, Link-Belt RS P.I.V. drives represent a major advance in direct-drive variable-speed transmission. It's the most compact mechanical 50 horsepower variable speed drive on the market.

Twin strands of high-load capacity chain operating between opposing conical wheels permit extreme compactness. The effective diameters of the wheel faces are altered during operation, changing their ratio and the output shaft speed accordingly . . . providing smooth, positive, accurate speed adjustment between maximum and minimum settings. Constant hp or torque is maintained over the complete speed range.

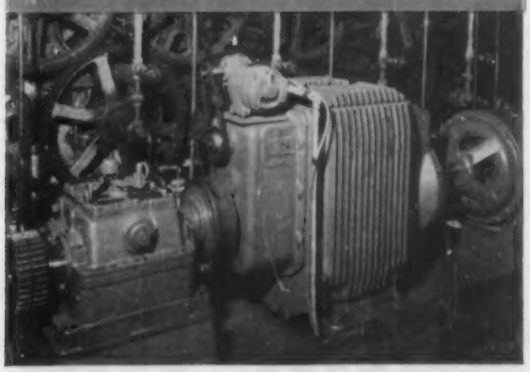
Link-Belt RS P.I.V. drives are all-metal and pressure-lubricated. Capacities to 50 hp, with speed variation ratios up to 5.5:1. For full details, contact your nearest Link-Belt office. Ask for new Catalog 2874.

15,357



RS-33 P.I.V. with twin chain arrangement for capacities to 50 hp. Inset shows close-up of unique all metal single roll chain construction.

**47-ROLL PAPER-MAKING MACHINE** uses Link-Belt RS P.I.V. on primary drive. The RS P.I.V. powers a two-speed gear drive which enables paper speeds to be varied over two ranges . . . 4 to 16 yards per minute and 12½ to 50 yards per minute.



LINK-BELT

P.I.V. VARIABLE SPEED DRIVES

**LINK-BELT COMPANY:** Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

# FROM WASHINGTON . . .

## *Navy Goes Overboard for Hydrofoils*

The Navy is eyeing hydrofoil boats as a major defensive weapon against submarines. It recently let a $2-million contract to Boeing Aircraft to build a 110-ft, 100-ton hydrofoil. The Navy specifies that the boat be equipped with torpedoes and submarine-detection equipment, and have a normal cruising range of 2000 miles, and a 700-mile hydrofoiling range.

**Top Navy brass told the House Committee on Science and Astronautics that they want hydrofoil vessels up to 1000 tons.** This may not be the upper limit for such boats.

Rear Adm R. K. James, Chief of the Bureau of Ships, says hydrofoils show "great promise of being extremely important in the antisubmarine-warfare effort."

**Varying lift capabilities of hydrofoils to adjust to water-surface changes is the biggest problem to be solved, the Navy says.** There are four basic hydrofoil designs that have had varying degrees of success. They are: tandem-submerged foils, surface-piercing ladder foils, surface-piercing V-foils, and the Grunberg configuration consisting of submerged after-foils with surface-skids forward.

**The Navy is building a submerged-foil boat with a sensing device to adjust the foils for water-surface changes.** The Maritime Administration is doing research and development on an 80-ton, 60-knot hydrofoil with V-type foils. Canada has built a 70-knot ladder-type hydrofoil boat that weighs 17 tons. Tests have been so successful that the Canadians are now planning a 200-ton model.

## *Shipboard Equipment for Satellites in Offing*

The Navy's transit-satellite navigation program will require special shipboard receiving equipment. So far, however, the Navy has not released enough information on the requirements of the equipment to allow design engineers to start work.

**Potentially, there is a big market for such equipment.** Not only will all major naval vessels need to be outfitted with receiving gear, but merchant ships and possibly aircraft as well.

**Industry has come up with some rough cost estimates of shipboard equipment.** The best guess, based on the limited information Navy has given out, is that it will cost around $1500 to outfit a merchant vessel with equipment that will provide navigational fixes accurate to ½ mi. Pinpoint navigation for naval vessels is expected to cost up to $60,000 per ship.

## *House Pushes Machine Translation*

A national center for machine translation will be required in the near future. That is what the House Committee on Science and Astronautics says after a round of hearings on the matter. Such a center would have branches in specific areas throughout the world under the coordination of one agency.

**A report just released by the committee raps the National Science Foundation for foot-dragging in this field.** The report states that "The National Science Foundation, although participating in this research program on mechanical translation, is not assuming the predominant leadership role that is expected of the Foundation."

**Army-financed research being done by the National Bureau of Standards is the best approach to machine translation, according to the Committee.** In the long run, the Committee feels this method of syntactical analysis will produce the best readable translation as far as sentence structure is concerned.



CIRCLE 13 ON READER SERVICE CARD→

This cylinder for a hydraulic press was cast and machined in a Blaw-Knox Steel Foundry. Weight—231,000 pounds.

# Blaw-Knox Steel Foundries have machine capacity to handle the most unusual product requirements

Planing, turning, milling, or boring the most unusually dimensioned casting is no problem in a Blaw-Knox Steel Foundry. There you will find planers up to 15 feet × 15 feet × 36 feet, lathes with an 84 inch swing, and planer type milling machines up to 6 feet × 6 feet × 25 feet. In the same machine shops, you will find the smallest precision tool room equipment.

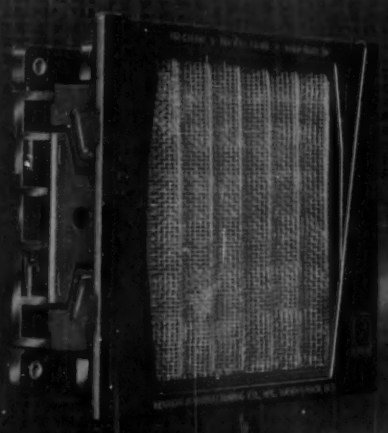
This huge line-up of tools is part of the basic equipment of each of the five Blaw-Knox Steel Foundries. Because Blaw-Knox is one of the world's leading builders of rolling mills and industrial machinery, its machine shops are equipped to handle all of the operations necessary to finish a steel casting for assembly into the complete unit or sub-assembly.

Machining to exact specifications with a wide variety of tools is another way Blaw-Knox Steel Casting Service adds value to your product. There is no need to ship the rough casting to another location for machining. You have the advantage of a single responsibility from patternmaking to shipping.

If you design or build a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

**BLAW-KNOX**

*Steel Castings*



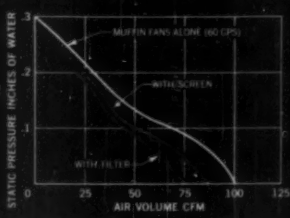
# ROTRON MUFFIN® FAN

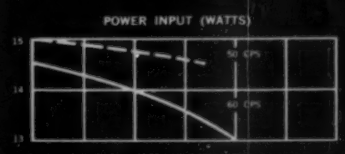
An original aerodynamic design that provides a high air performance of 100 CFM free delivery and is capable of developing sufficient pressure for operation through a washable dust filter and tightly packed electronic equipment. Its high air performance, extremely compact size (only 4 1/16" square by 1½" deep) and its moderate cost, provides for the first time efficient forced air cooling for equipments where cooling has been previously prohibitive.

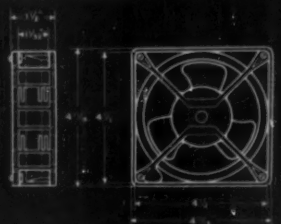
As a design innovation, Rotron now offers the MUFFIN FAN in combination with a FILTER BOX which is perfectly matched to the pressure building capacity of the fan. The FILTER BOX locks in place between the Grille Frame and the Venturi Fan adding slightly less than ¾" to the overall depth. The filter material is Air-Maze Media P96A, a high velocity, high efficiency, viscous impingement type that is permanent and is washable in hot water.

Power requirement is 105 to 120 VAC, 60 cycles, single phase. Electrical connection is made to convenient terminal lugs accepting standard 18 gauge lamp cord.

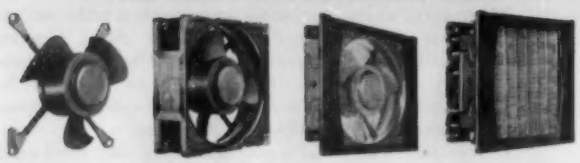
# FILTERED COOLING



**CHOOSE FROM 4 VERSATILE PERFORMERS**



"MUFFIN SKELETON FAN" "MUFFIN VENTURI FAN" "MUFFIN GRILLE FAN" "MUFFIN FILTER FAN"

**MUFFIN FAN SELLING PRICES**

| | 1-9 | 10-24 | 25-49 | 50-99 | 100-499 | 500-999 | 1000 up |
|---|---|---|---|---|---|---|---|
| Skeleton Fan | $12.80 | $11.50 | $10.20 | $8.95 | $8.30 | $7.35 | $6.40 |
| Venturi Fan | 13.70 | 12.30 | 10.95 | 9.60 | 8.90 | 7.90 | 6.85 |
| Grille Fan | 14.50 | 13.05 | 11.60 | 10.15 | 9.45 | 8.35 | 7.25 |
| Filter Fan | 15.85 | 14.40 | 12.95 | 11.50 | 10.80 | 9.70 | 8.60 |

WRITE TODAY FOR COMPLETE DETAILS ON THE REMARKABLE ROTRON MUFFIN FAN . . .

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# THE ENGINEERING WEEK

## Pneumatic Carrier Routed by Acoustics

LONDON—A British company has used electronics and acoustics to redesign the time-honored pneumatic-tube carrier system. This new document-carrier, developed by Dialled Despatches Ltd, links from 10 to 45 separate and intercommunicating stations moving cartridges at speeds up to 30 mph.

To operate, the sender dials the number of a required station on the soundhead positioned on the dispatch carrier, uncovering reeds tuned to particular frequencies. When the carrier approaches its station, a microphone picks up the reed note and with an amplifier operates an electronic relay controlling a deverter which deflects the carrier into its station.

The system's single transmission tube is of unplasticized PVC. Standard tube dia is $2\frac{7}{8}$ in. internal and $3\frac{1}{4}$ in. external when internal dia of despatch carrier is 1.8 in. Howeve:, when the internal dia of the carrier is 2.8 in., a transmission tube is available with 4.8 in. external dia and 4.5 in. internal dia. Depending on bend radii of the transmission tube, carrier length ranges between $5\frac{1}{2}$ in. and $9\frac{1}{2}$ in. for the 1.8-in. carrier, and between $8\frac{1}{2}$ and $14\frac{3}{4}$ in. for the 2.8-in. cylinder.

### HOW IT WORKS

Carrier has twin-telephone dials which expose tuned reeds. When the carrier is inserted into the transmission tube, the passage of air over the reed causes a chord to be emitted, peculiar to the tuned amplifier of one station. Electronic control units at the receiver stations have band-pass selectors so that slight signal frequency variations will have no effect. Plug-in numerals on the control unit chassis contain tone information and correspond to figures on the tone head, so that station codes can be changed easily on office replanning.

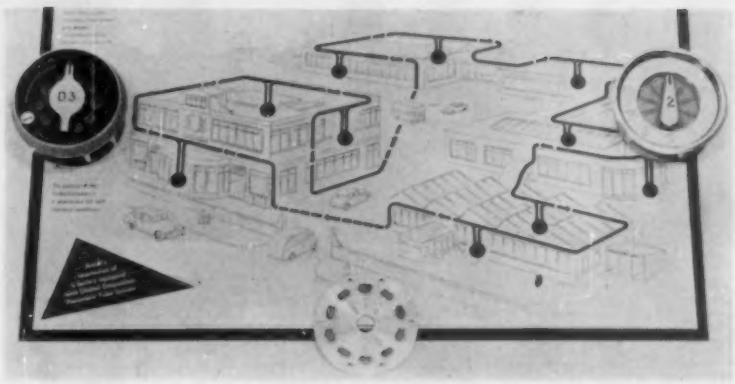
As the carrier travels through the tube, it passes a microphone at the approach to each station. But only when the tone emitted by the carrier is compatible with the tuned circuit of a particular amplifier circuit will the diverter be operated.

Automatic traffic control avoids collisions between carriers. A traffic switch, microphone switch, receiving switch, and junction switch, together form a series of electrical interlocks. If a carrier, already in the main transmission tube, has passed the traffic switch of a main station where another carrier is being injected, injection of the new carrier into the main tube is automatically delayed.

Airflow through the station branch tubes is only accomplished during insertion and removal of carriers to keep dirt out. Airflow through the main transmission tube is continuous, but if no carriers are sent for 15 min., the system exhauster is automatically stopped. Insertion of a carrier automatically restarts the exhauster.

If the carrier is incorrectly dialed or inserted, it makes two complete circuits of the system, and is then automatically ejected at a reject station which can also function as a normal station. If there's trouble in a control unit, the other stations needn't be affected, as each has its own main supply. Air exhauster unit is a multistage, high-speed turbine giving pulseless delivery and occupying only 5 sq ft of floor space.

—Nick Landon, London Bureau



**APPLYING ACOUSTICS to pneumatic-tube message delivery, Dialled Despatches, Ltd, has developed a system which can service up to 45 stations at speeds of 30 mph. Sender dials station's special number on the sound-head of the cylindrical carrier; this action uncovers reeds tuned to certain frequencies. Carrier microphone relays this electronic alert to a diverter which deflects the carrier into the desired station—dial at right serves for up to 10 stations; dial at left is pressed into service when up to 45 stations are in operation.**

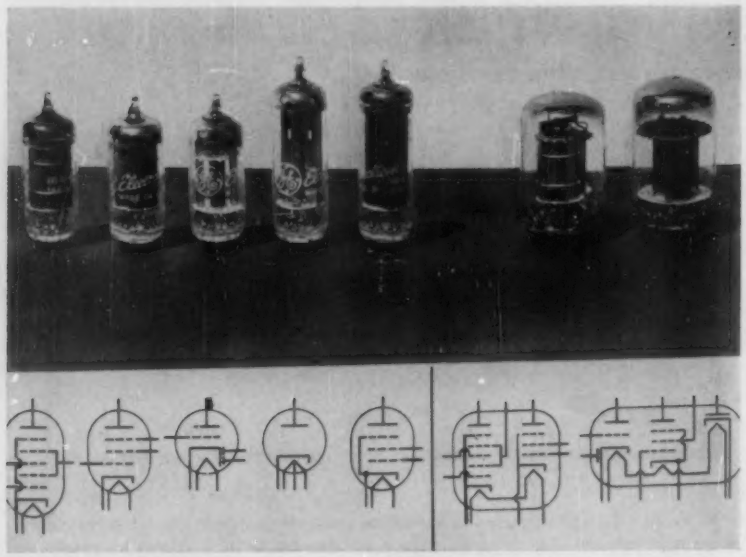
## Another Monorail Proposed for Los Angeles

LOS ANGELES—A transit system running at twice the speed of US mass transit average, and costing $529,700,000 has been recommended to the Los Angeles Metropolitan Transit Authority (MTA). The initial system would total 74.9 miles and consist of four lines extending out from Los Angeles, central business district to Covina, Santa Monica, Long Beach and Reseda.

The system would utilize 54-seat air-conditioned, lightweight cars, electrically propelled on pneumatic rubber tires on concrete tracks, and running mostly on overhead structures with some mileage at ground level. The track structure would be supported by single concrete columns. (*PE—Jan 25, p 15*).

The system would reach speeds of 80 mph, and would operate at an average speed of 37 mph for peak hours.

The report was made to MTA after eight months of study by the engineering firm of Daniel, Mann, Johnson and Mendenhall. ■



**TWO COMPACTRONS** are shown at right in comparison with the five miniature tubes (left) they replace in a radio receiving set. The compactrons combine in two units all of the functions of the five tubes (left to right, 12BE6, 12BA6, 12AV6, 35W4 and 50C5). These two and others in development at General Electric's Owensboro, Ky plants, will permit makers of radios, TV and high fidelity sets to reduce size of their cabinets.

## New 'Compactron' to Replace Radio, TV Tubes

NEW YORK—A new electronic device called a "compactron," replaces conventional miniature tubes to help achieve considerably less expensive, more compact circuitry for radio, television and high-fidelity sets. Developed by General Electric at its Owensboro, Ky plant, the device was demonstrated here in the form of a 2-compactron radio mockup, measuring 2½ x 2½ x 10½ in.

According to GE engineers, a television receiver could be designed with 10 compactrons replacing present set circuits that require 15 tubes and 3 diodes, or 24 transistors and 11 diodes; a 2-compactron 12-volt automobile radio could obsolete the present 4-tube car radio design; and monaural high-fidelity equipment could be built using 4 compactrons rather than 6 tubes or 11 transistors.

GE says the new device shows promise of wide use in industrial controls and instrumentation, as well as in 2-way communication equipment. In these areas, they say, the advantages of smaller size and multifunction capability at lower cost would be equally strong.

Development engineers said also that other circuit elements would conceivably be included in evacuated compactrons in the future to further enhance miniaturization, reliability and total cost savings. They said the line will eventually comprise 75 to 100 types.

W. F. Greenwood, manager of marketing for the Owensboro facilities, stated that prices have not been established for compactrons, but that savings in material and labor would eventually make possible an estimated 20% lower price per function than tubes, and considerably lower than transistors.

Greenwood predicted that compactrons eventually would replace most present-day 7- and 9-pin miniature tubes, as manufacturers continue to make progress in reducing equipment sizes to meet the "small-package" appeal of transistorized units.

C. D. McCool, manager of product design at Owensboro, said that new metallurgical developments, leading to improved thermal efficiencies, make important contributions to compactron design and operation.

Included in these, he said, is a new anode material that reduces by as much as 40% the heater power required by the cathode. Another development is a clad material expected to be incorporated in future compactron units that improve both the hot strength and thermal efficiency of cathode elements.

Arthur F. Dickerson, Owensboro manager of product planning, explained that single-function compactron designs, which would replace conventional tubes on a one-to-one ratio, were necessary either because the power requirement was close to maximum limitations for one unit, or because of the dictates of good design practice imposed by the need for high voltages in some functions.

McCool said that compactrons now scheduled for production use 12-pin connections in a circle ¾ in. in dia and a dome-shaped envelope exhausted from the bottom. They are about 1¼ in. in dia and vary in seated height from 1 to 2¾ in.

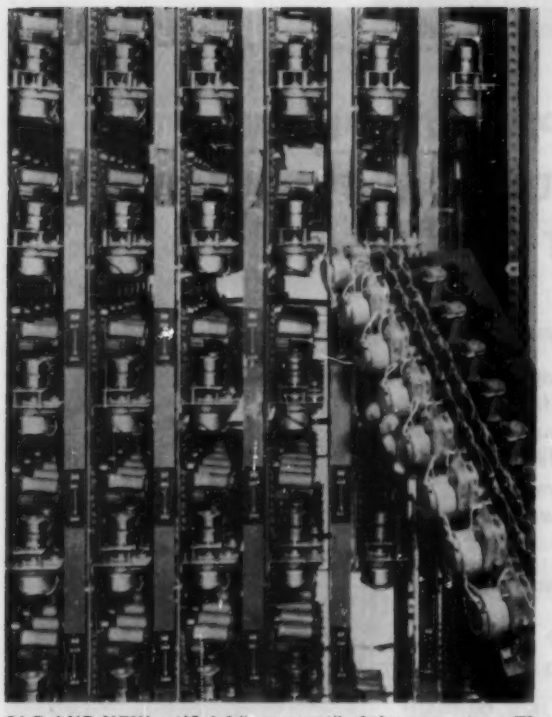
Twelve connections were chosen, McCool added, to accommodate multifunction elements within the unit. They are spaced to provide latitude in lead separation, with a minimum of interaction at the base. The design avoids undue clustering of associated components, and, the large 12-pin circle adapts better to the larger 1½-in.-dia designs of high power output tubes.

### FUTURE USES CITED

The large-dia circle of the 12 connector pins, McCool said, also adapts the compactron well to printed circuitry, permitting adequate isolation of the plate from other electrodes in high-voltage operation. This isolation, with "blank" pins on either side of the plate connection, provides an arc (high voltage) rating in the order of 10,000 volts dc, he said.

Among assembly economies possible with compactrons, McCool stated, is the use of an integral heater supplying as many as three separate cathodes. This eliminates four heater welds and "translates to lower production costs and inherently greater reliability in the device.

"While the integral heater is not a new development, this is the first large-scale application where elements with three heater functions have been combined in one continuous unit," McCool concluded. ■



**OLD AND NEW** artificial "nerve net" of the perceptron. The rack at left holds 512 association units of the Mark I in banks of eight. These units are electromechanical—dc motors driving relays. At right are electronic association units composed of ceramic magnetic cores. Developed by Aeronutronic, it will be used in the Mark II perceptron being designed by CAL. Transistor circuits are used with the devices to help carry out decision-making functions.

## MIND to Speed Perceptron

NEWPORT BEACH, CALIF—The Mark II perceptron being designed by Cornell Aeronautical Laboratory will probably incorporate the newly developed Magnetic Integrator Neuron Duplicator (MIND) recently developed by Aeronutronic, a div of Ford Motor Co. The Mark I perceptron (*PE—July 4, p 17*) uses electromechanical devices; the association units are dc motors driving relays. These units require a considerable amount of space, and at the same time are slow to learn.

The electronic unit, based on the principle of BIAX computer elements, is about a fourth the size of a penny and is composed of a magnetic core with an inner hole through which wires are strung. The ceramic core is capped with a metal washer and again wound with wires.

Joseph K. Hawkins, manager of Self Organizing Machine Research at Aeronutronic, says the artificial neuron stores or "remembers" the effects of past events by increasing or decreasing the amount of flux stored in a magnetic circuit. Memory contents are read simultaneously at electronic speeds from a series of similar artificial neurons. In this way the sum total of past experiences controls the decision "response" made by a network of MIND elements.

#### EXPECT 10,000 A-UNITS

Best guess by members of CAL is that the Mark II will have about 10,000 A-units. But, cautions Hawkins, "we are still a long way from building anything even approaching the complexity of the human brain with its approximately 80 billion neurons." An equal number of MIND devices, stacked one atop the other, would reach 80,000 miles.

During testing, the MIND device has "learned the rules" for giving correct answers—in coded language—in response to a limited number of electronically stated problems, Hawkins disclosed. The problems could also be posed visually, by sound, or by other signals corresponding to human senses. ■

## New Epoxide Building Blocks

NEW YORK—Union Carbide Chemicals Co is now commercially marketing a new series of epoxides—the basic monomer building block for epoxy resins for laminates, coatings, adhesives and castings. Produced from peracetic acid, the new epoxides are making possible resin systems with better color stability, higher strength at high temperatures, easier fabricating characteristics, and extended pot life. For example, a new laminating resin developed by Brunswick Corp for missile parts, and based on UCC's epoxide Unox-207 is the first to pass the requirements of MIL-R-9300A for missile radome laminates. In the coating field, Schenectady Varnish Corp has developed a one-component transformer encapsulating resin based on Unox-201 that will meet Class F (311 F) and higher ratings. Casting resins based on Unox-206, the third epoxide, are reported to have unusual impact strength above 450 F. Adhesives based on Unox-207 show lap shear strengths of 800-1000 psi. ■

DOW | *Now in magnesium and aluminum*

# NEW DOW DEVELOPMENTS PROVIDE DESIGNERS WITH ADDED ADVANTAGES IN LIGHTWEIGHT MAGNESIUM

**Lightness, ease of fabrication and other features of magnesium contribute to improved designs for many products—from airplanes and missiles to luggage . . . from industrial machinery to cameras. Now, new developments by Dow provide greater design flexibility than ever before—in fabricated components you require, in materials and processes to facilitate your plant's operations.**

New sheet is bent without heated dies.

## NEW CLOSE SHEET TOLERANCES HELP SOLVE WEIGHT PROBLEMS

When the design problem is stress distribution versus weight, the new, closer magnesium sheet tolerances available from Dow upon special request offer a real advantage. As shown below, new tolerances are one *half* of standard tolerances. This permits designers to provide for required stress distribution, based on minimum thickness, *without* having to accommodate all the extra weight that might occur with the maximum thickness permissible with conventional tolerances.

Especially useful for aircraft and missile designers, this close tolerance sheet is also suggested for use in air-transported equipment or wherever minimum weight is critical.

COMPARISON OF TOLERANCES

*48-inch-wide sheet*

| Gauge | Close Tolerances | Standard Tolerances |
|---|---|---|
| .032" | ±.0013" | ±.0025" |
| .040 | ±.0015* | ±.003 |
| .050 | ±.002 | ±.004 |
| .063 | ±.002 | ±.004 |
| .071 | ±.002 | ±.004 |
| .080 | ±.002 | ±.004 |
| .090 | ±.002 | ±.004 |
| .100 | ±.0025 | ±.005 |
| .125 | ±.0025 | ±.005 |
| .160 | ±.004 | ±.008 |
| .190 | ±.005 | ±.010 |

*For HM21A-T8 .040" close tolerance is ±.002".

## NEW SPECIAL BEND SHEET ELIMINATES HEATED DIES

Critical bends can now be easily formed at room temperature — *without heated dies*—using Dow's new AZ31B-O Special Bend Sheet. Without cracking, it bends through an angle of 90° around a mandrel radius as small as two times the nominal sheet thickness. Among many suggested applications are housings for electronics equipment, truck cabs, shipping containers, plus such military uses as maintenance and personnel shelters and housings for ground support equipment.

BEND FACTORS

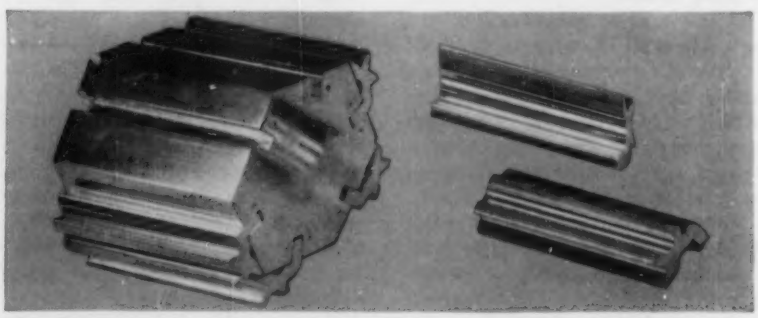
| Nominal thickness | Longitudinal bend factor | Transverse bend factor |
|---|---|---|
| 0.040"–0.100" | 2.0 | 2.5 |
| 0.101"–0.190" | 2.5 | 3.0 |

Tensile yield strength meets Federal Specifications AA-M-44.

## PRECISION MAGNESIUM EXTRUSIONS CUT MACHINING COSTS

Dow precision magnesium extrusions provide exact-tolerance finished or semi-finished components and eliminate many costly multiple machining operations. Exacting tolerances are even possible with sharp V's, deep notches, thin slots, sharp serrations, as well as precision diameter tubing. And with precision extrusions, cost of materials is also frequently less because high-property alloys to withstand extensive machining are not needed.

Applications include bearing blocks, impact extrusion stock, parts for business machines, printing furniture, screw machine stock, shaft shear keys, spacers and airfoil configurations.



Exact-tolerance extrusions cut machining costs.

## NEW FINISHES BROADEN APPLICATIONS FOR MAGNESIUM

*Porcelain enamel*, a practically foolproof way to avoid corrosion, can now be applied to magnesium, using a Dow-developed pretreatment to assure adhesion. Suggested applications—display signs, building panels, cooking ware, home appliances, engine parts.

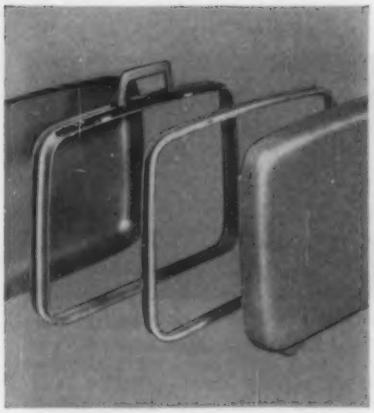
*Dow 20 chrome pickle* provides a uniform paint-base for casting alloys with high aluminum content.

*Dow 21 ferric nitrate bright pickle*, as a spray or dip, provides long-lasting protection under clear baking enamels or lacquer.

*Clear anodic coating*, applied in less than a minute, provides maximum protection under lacquer or varnish, which may be tinted in a wide range of colors.

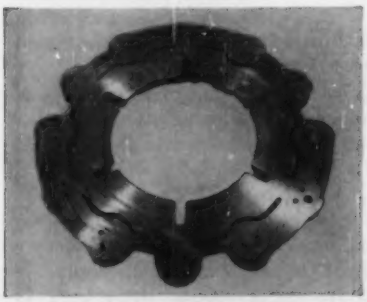
*Nickel plating*, by immersion instead of electroplating, simplifies processing, improves nickel surface. For electronics equipment, printing plates and cylinders, other surfaces requiring extreme wear resistance.

*Vinyl* may be laminated before cold-forming magnesium sheets—also bonds to hot-formed shells. For luggage, carrying cases, other applications.



Vinyl-laminate adds sales appeal to carrying cases, luggage.

## DOW CASTS MAGNESIUM IN INTRICATE DESIGNS



Casting incorporates tubeless passages.

Cast-in tubeless passageways, thin sections, close tolerances and other intricate designs are all available in castings made in production quantities at Dow's sand and permanent mold foundry.

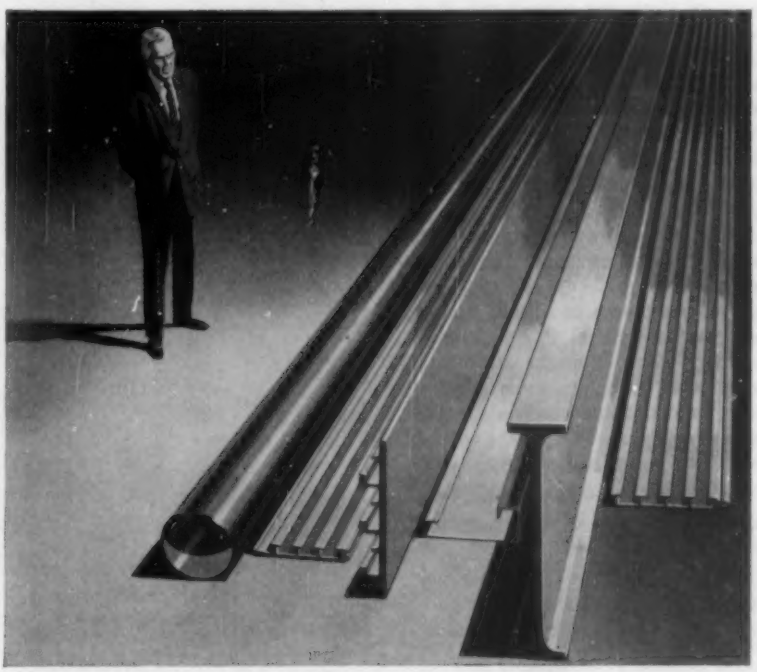
## NEW ALLOY ELIMINATES STRESS RELIEF AFTER WELDING

A newly developed Dow alloy for magnesium sheet and plate, ZE10A, containing zinc and rare earth metal, does away with the need for stress relief after welding . . . particularly advantageous in building large structures. Suggested applications – large shipping and storage containers, even tank-trailer bodies. So that designers can take full advantage of this new sheet and plate material, Dow also provides magnesium extrusions in alloys requiring no post-welding stress relief.

## VAST PRODUCTION FACILITIES FOR MAGNESIUM AND ALUMINUM

The Dow Metal Products Company offers a new die casting plant, a sand and permanent mold foundry, a fabrication plant plus the huge Madison plant for sheet, plate and extrusions. At Madison, for example, is the giant 13,200-ton press that extrudes king-size sections of magnesium or aluminum—up to 30 inches across and 80 feet long.

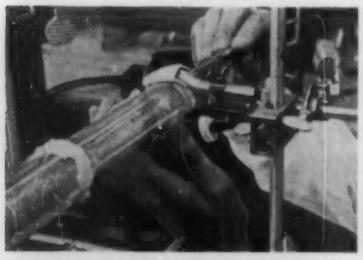
For more information about the new magnesium developments shown here, or for help in any design or fabrication problem involving magnesium or aluminum, contact the nearest Dow sales office. Or write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Department 1053DZ7-11.



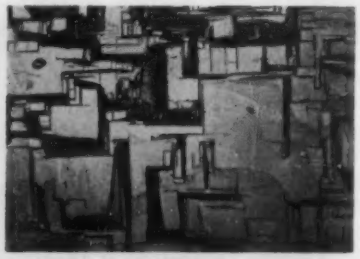
King-size extrusions make possible freedom in design.

DOW **THE DOW METAL PRODUCTS COMPANY**

*Division of The Dow Chemical Company*



**CRYSTALS ARE REMOVED** after vapor growth has taken place. Making complex structures of many thin-film layers permits construction of semiconductor devices with more precisely controlled operating characteristics than before.



**EPITAXIAL GROWTH** means the top layer of one semiconductor automatically duplicates the same crystal structure as the one beneath it. This takes advantage of the properties of each material. Above is typical growth on a silicon substrate magnified 350 times.

## Semiconductor Growing Process Eliminates Manual Assembly

YORKTOWN HEIGHTS, NY—Vapor growth, a new process that arranges atoms of one material on another, has been developed by IBM. It is expected to produce functional circuit building-blocks in one continuous operation.

Its broad significance, says IBM, lies in the possibilities offered to device designers and manufacturers for arrays of electronic components that can be faster, more complex and more compact. Specifically, the vapor-growth process holds the promise of precise and automatic control for volume production of the more complex functional units—it eliminates manual assembly of arrays and devices.

The process takes place through the intermediary of semiconductor iodide vapors. These pick up the semiconductor (germanium or silicon) from a piece of the material at a high temperature. The vapors move into a cooler zone where the semiconductor grows from the vapor onto a suitable single-crystal seed. The process can be carried out in one of two ways:

- A continuous flow of gas carries the vapors in one end of a furnace and out the other.
- A closed tube is used and the vapors recirculate, carrying the semiconductor from the hot end to the cooler end.

It is possible to incorporate selected impurities in the growing semiconductor at the cooler end during the growth process.

Semiconductors are now made from melt-grown material by cutting it up into minute pieces and introducing the desired series of impurities by separate operations of alloying or diffusion, followed by hand assembly under a microscope.

Vapor growth permits the device to be grown in one operation, layer by layer, from the vapor. Low temperature is the key to layer-by-layer growth. Growth from the melt, alloying or diffusion all are carried out at high temperatures and this disturbs the layers as new ones are formed. ■

## Ceramic Core Converts Auto Exhaust

TOLEDO—A converter that reduces unconsumed hydrocarbons in car exhaust to tiny particles of harmless ash has been developed by Rollins Research Industries here.

The device is made to be attached to the exhaust manifold of new or used cars or trucks. It's based on a ceramic core, made of a special type of clay, which contains its own catalyst. The catalyst solidifies gases into particles of crystallized ash.

Quantity of ash is so small that 1000 gal. of gasoline produces only about a thimbleful. All poisonous or offensive gases and other undesirable elements are said to be eliminated.

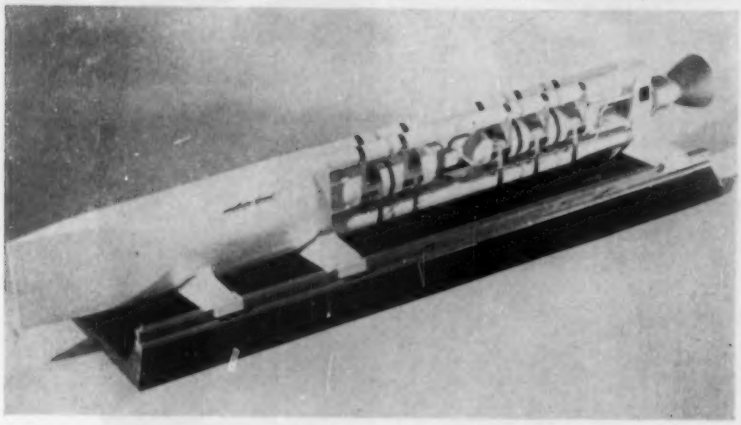
The 2½ lb ceramic core, designed to last the lifetime of a car, is suspended in a metal housing. In one test, the converter was attached to a car engine which ran continuously for four hours without harmful results to persons in the same closed room.

A large national corporation supplying the automobile industry and motor services is negotiating for primary rights to assemble and distribute the converters, supplying them both to manufacturers and retail outlets. ■

## Lost-wax Casting from Ceramic Shelling

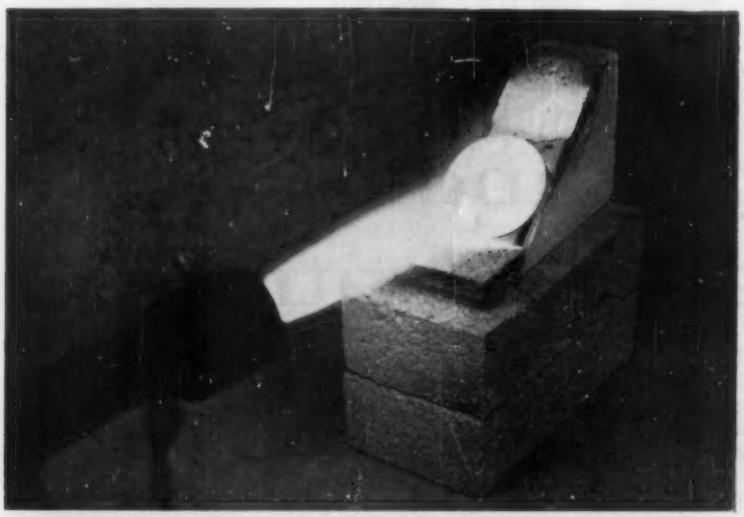
**Complex castings weighing up to 100 lb or 40-in. long are now possible with a ceramic shell process developed by Arwood Co, Groton, Conn. The technique, an adaptation of the lost-wax investment process, also gives more consistently good surface finish, finer grain size, and can handle more complex shapes. Similar to the dip-sprinkle steps in Glascast (PE—Oct 14 '57, p 68) the process builds up a ceramic shell on a wax pattern. After the wax is melted out, the ceramic shell can then be used as a mold for molten metal with no backup or support. Difference here is the exclusive formulation of the slurry dips and the mold material.**

## Objective: Constant Acceleration to Test Space Components



This preliminary design of Aerojet-General's rocket sled, when mated with company's newly developed controllable-thrust liquid engine, promises to be one of the most advanced missile research testing vehicles designed to date. Sled will accelerate a 3000-lb payload to Mach 2 or faster or decelerate at a negative rate to 20 g's. Four longitudinal members serve dual rates as pressurizing gas tanks and part of the main structure. High-strength steel bands elastically suspend the propellent tanks between the four longitudinal gas-pressure tanks. Controllable-liquid engine gives varying thrust range of 50,000 to 150,000 lb. Starting weight is about 9 tons including the payload which can be pushed ahead in a separate sled or carried within a nose section joined to the sled.

## Material Forms Its Own Protective Coating



A composite ceramic graphite body, developed at Boeing Aerospace Div in Seattle is capable of spontaneously forming its own protective coating against heat and oxidation—two of the primary enemies of hypersonic flight. The maximum tension and compression capability of the material is about double that of standard graphite at room temperature. When suddenly plunged into temperatures above 2200 F, the protective layer forms immediately—material in photo is under test in 2600-F oxyacetylene blast. A typical composition consists of 50% graphite, 24% molybdenum disilicide and 25% titanium boride plus minor ingredients to promote bonding. Layer appears in one composition as a smooth adherent, nonporous, yellow-brown film about a thousandth of an inch thick. As temperature and exposure to oxidation increases, the layer thickens and becomes more resistant.

## Austrian Research Pays Off

VIENNA—Pure and applied research, carried on by 138 Austrian institutes, has achieved considerable success despite shoestring budgets, the Federal Ministry of Trade and Reconstruction reports.

Austrian research institutes are divided into 37 factory labs, 16 co-op labs or craft organizations, 15 institutes of federal agencies, 17 institutes of provincial or municipal governments, 25 polytechnic school labs and 23 institutes at other schools.

Foreign orders contribute heavily to the financial well-being of the public institutes, the report finds. The Electron-Microscopy Institute of Graz, for example, gets orders from large US enterprises such as DuPont. And the Research Institute for Combustion Engines, also of Graz, obtains about 70% of its R & D contracts from US, Japan and other countries.

Though deriving scant public support, research is aiding the economy, the report says. The research center of the nationalized steel mill, Gebr. Boehler AG, operated on a $192,300 budget last year, but got returns on its patent licenses of $653,800.

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### CZECH-SOVIET COOPERATE ON R & D

VIENNA—Behind the Iron Curtain, the Czech State News Agency (CTK) says that Czechoslovakia's 400 scientific research institutes and labs operate on budgets of about $306 million annually—2% of the state's gross industrial production. This excludes work underway at universities and other higher institutions.

The news agency reports further that technical cooperation with the USSR and other countries in the Soviet orbit, is increasing. A protocol signed recently commits the USSR to provide the Czechs with technical data for automating the metallurgical and chemical industries. The Soviets will also pass on data for the food, building and agricultural industries.

In return, Czechoslovakia will give the USSR technical assistance for a tube-rolling mill, and techniques for producing medical equipment and consumer goods. The agreement further calls for joint projects at scientific and research institutes and in design and construction. ■

Thousands of Honeywell T654A Indicating Temperature Controllers have already proved their superiority in industrial plants throughout the country.

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The new Honeywell T654A is a dependable, low-cost indicating temperature controller for use in rugged industrial applications. It indicates and controls temperatures in various ranges on an evenly graduated scale accurate within 1% of scale range.

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The indicated temperature and set point are both clearly visible through a magnifying window. The set point is changed simply by turning a knob on the front of the case.

The unit can be surface-mounted or flush-mounted. And various types of wells are available for numerous applications requiring bulb protection.

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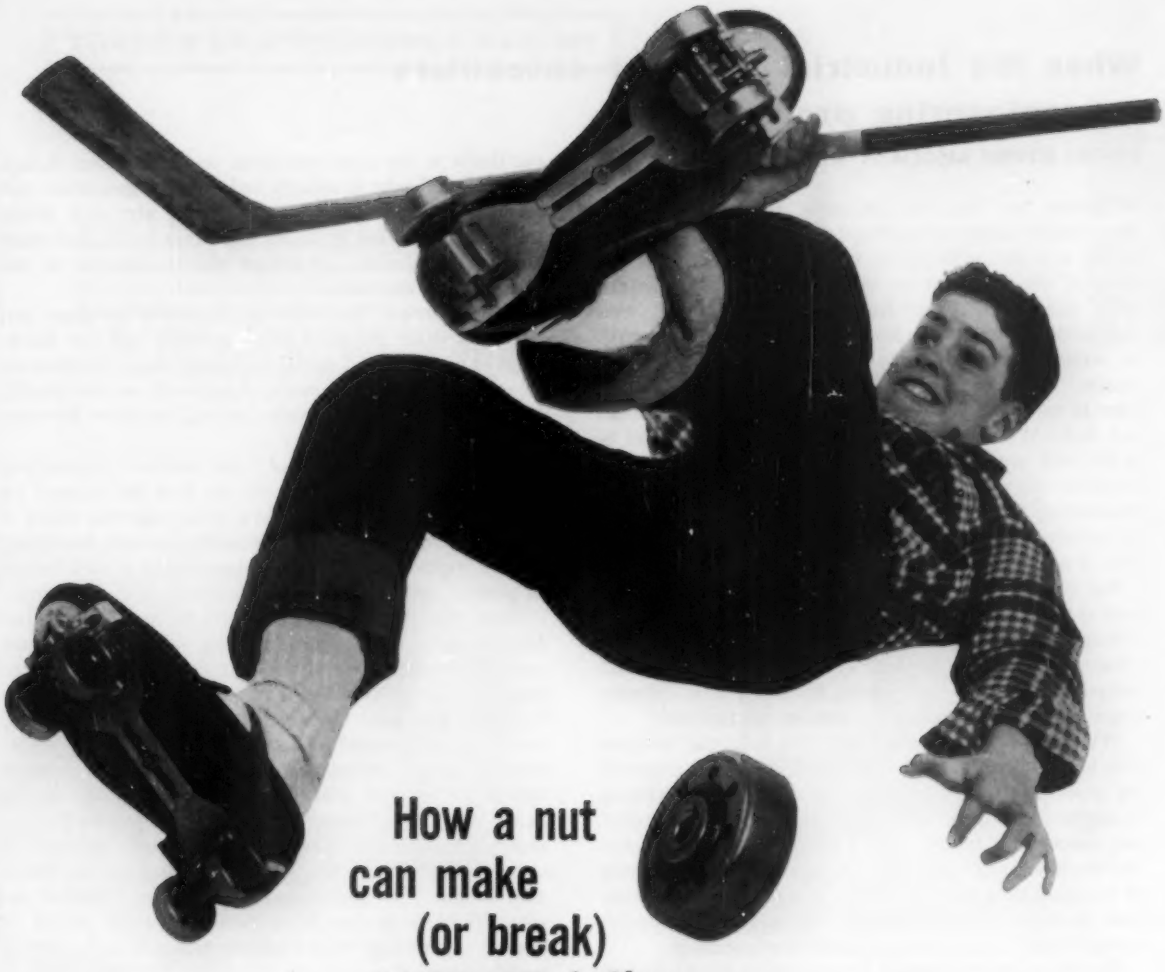


# How a nut can make (or break) your reputation

## *. . . and even bring in re-orders*

A nut comes loose. A wheel comes off. And down comes Billy! No great loss, except perhaps to his dignity. But when a lost nut knocks out a rock drill, or a tractor, or a piece of the heavy equipment that *you* make—then what?

*Down* goes the machine! *Down* goes production—for no telling how long! *And down goes your reputation as a maker of quality equipment!* You can blame it on the nut, but your customer blames *you!*

This kind of embarrassing and costly "Reliability" failure simply cannot occur when you specify Elastic Stop® nuts for critical bolted connections. For no matter how rugged or repeated the shock or impact, no matter how bone-shaking or constant the vibration . . . Elastic Stop nuts *simply will not work loose!*

Elastic Stop nuts with their exclusive, vibration-damping nylon locking inserts are nothing new. They have been widely used for over 20 years by an increasingly large number of quality-conscious manufacturers who have learned that Elastic Stop nuts give built-in insurance against product failure—the kind of reliability that shows up in customer maintenance records and adds up to reorders. Let us send you information showing how manufacturers have protected the reputation of their products with Elastic Stop nuts. Ask for Bulletin 5901. Dept. S47-745, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

*for the ring of reliability*

**ELASTIC STOP NUT CORPORATION OF AMERICA**

# When the Industrial Designer encounters an engineering problem . . .

**BROOKS STEVENS ASSOCIATES, Milwaukee**

■Chances are that the industrial designer recognizes the technical nature of a design problem about as quickly as the engineer with whom he is working. This is because of the attributes we must have to succeed in our field; also because our training and experience tend to develop as good a mechanical sense and intuitive grasp of many types of technical matters as most engineers possess. We also recognize our limitations: We cannot hope to solve advanced problems in mechanics, hydraulics and such. We do not think we should even be asked to tackle such problems; these are up to the engineers with whom we are working—or if they cannot help—to outside engineering help. Capable industrial designers feel free to consult engineers whenever necessary, and do not consider it a sign of weakness when they must do so.

But it is also true that our approach to design problems is often different from that taken by most engineers. Perhaps to avoid getting bogged down by engineering "don'ts," we first try to think of alternative materials and components and ways of making things—or even different concepts of how a product can perform its function.

We know from experience that the industrial designer who honestly tries to understand and cope with engineering problems as such—despite his lack of formal training in engineering—is the one who wins the engineer's respect and cooperation fastest. The fact that the designer and the engineer must also have in common a sound grasp of the limitations and possibilities of materials and production processes and equipment will also help establish mutual respect and a more productive relationship.

The engineer gains respect for our potential contribution when he realizes that we are more than simply "stylists" and that there is room and need for both of us in the name "designer" and the function it represents.

But other obstacles remain, in even the best engineer-industrial designer teams. We designers are much more influenced by what the consumer is going to use the product for and how it will be applied. The engineer's proper preoccupation with the problems of making a product work as well and as efficiently as the limitations imposed by management will allow, tends to becloud for him the basic purpose of the product. It is generally we who are most aware how much visual appeal and ease of operation counts in the consumer's decision to buy one brand rather than another.

Sometimes this means the engineer cannot understand our desire to see more automatic operation, even though we also emphasize simplicity and better organization and placement of controls. It also explains why such things as the avoidable use of screws and other visible fastenings on exterior housings are always objectionable to us and seldom to the engineers.

You might say that although industrial designers and engineers share the mechanical aptitude and the knowledge of materials and methods required to see the answers, we seldom achieve them easily. Apparently, we lack parallel lines of thought and approach—at least, when we first start working together.

The engineer who has had a few successful experiences with us comes to realize, as we do, that the product on which we work together will be a better one than either of us would create alone. We generally can see developing in such engineers an increasing appreciation of such factors of product appeal as color, finish and general appearance.

Does this growth of the capacity to work with industrial designers mean more and more sharing of the same areas of responsibility of product development by engineers? No! Applying the mathematics of mechanics and hydraulic flow must remain the province of the engineer, as well as such technical detail work as specifying proper threads and gear ratios. On the other hand, the engineer should not be asked to investigate and evaluate such factors as the influence of human physical limitations on product design. Readability, color and the esthetic relation of shape to function are also the tasks primarily of the industrial designer. To put it another way, the industrial designer is likely to contribute more during the period of "bench engineering" than when the technical or theoretical problems are being resolved.

The industrial designer could probably carry out this and his other functions even more effectively than he does now—and at an earlier point in his career—if he were better equipped by the industrial design schools to break down and evaluate the problems of product design. Some of the schools have recognized this need—in relation to materials for example. Courses are now being given to some industrial design students that stress the underlying physical, chemical and mechanical phenomena relating one material to another and differentiating among others.

We have noted signs of change in engineering education also. In fact, some of us here at Brooks Stevens Associates have been lecturing at the Milwaukee School of Engineering for the past two years.

We hope these indications of change will spread, because the newly graduated engineers of today are still lacking in flexibility—and even in curiosity about alternative methods of solving product design problems. They tend to take recourse far too quickly in established data sources and authorities, rather than attempting to think things through first for themselves.

The older engineer who has been out of school long enough to have acquired an assortment of experience does tend to look for answers first in his own experience and resources. This is particularly true where the manufacturer employing him has a record of successful products. ■

**This article resulted from a group interview by a PRODUCT ENGINEERING editor with industrial designers Brooks Stevens, James Floria, John Hughes, Gordon Kelly, David Nutting. The interview began with the question, "What happens when the industrial designer encounters engineering problems requiring technical data and background (or training) for their solution? What is the industrial designer's reaction and procedure—particularly, *on the spot?*"**

## TRENDS IN APPEARANCE DESIGN

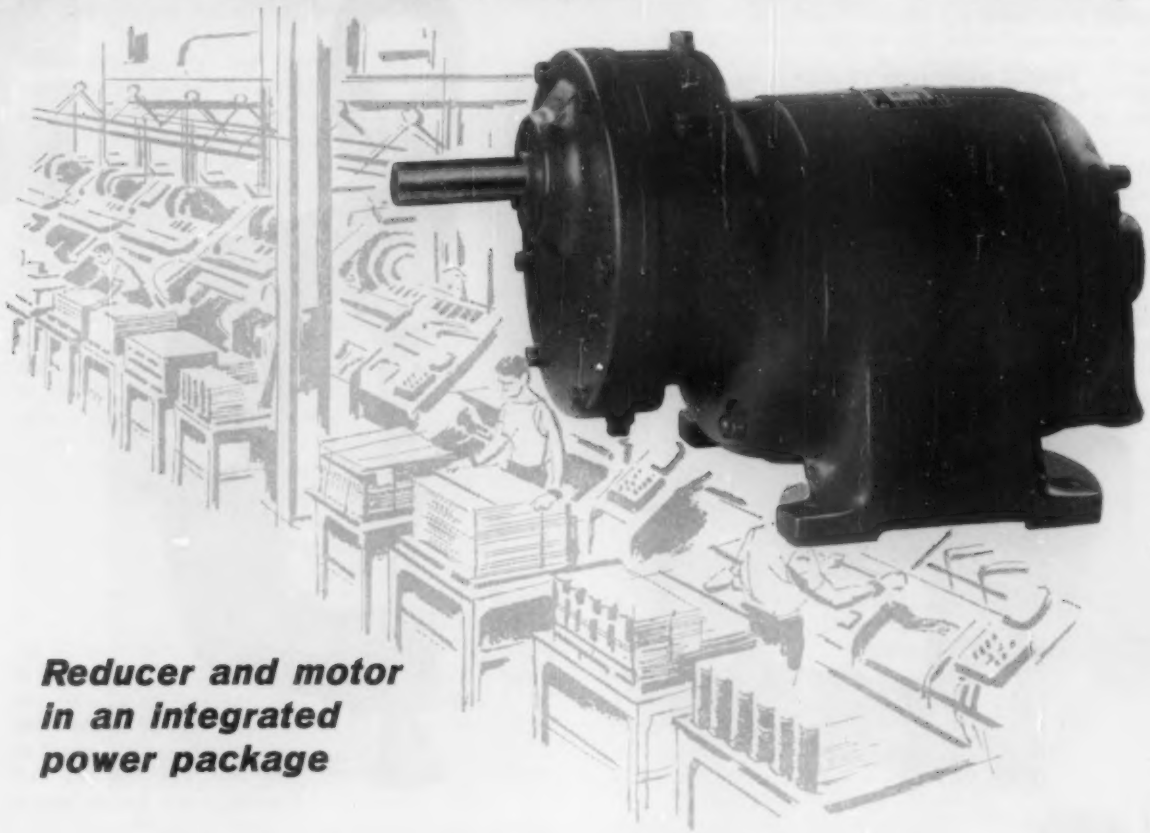
**MOBILE HARDNESS TESTER** is for use on materials and components so heavy or bulky that they must be tested where they are. Cast aluminum C-clamp holds instrument in place while indenter head checks hardness in one of two different load ranges, using interchangeable spring units. Angled C-shape of clamp, gives this device its distinctive look. Introduced by Wilson Mechanical Instrument Div, American Chain & Cable Co, Inc.

**THIS GAGE MEASURES** and controls vacuum systems continuously over a range of 0.001 to 20 microns of mercury. Designed by Stowe Myers, industrial designer of Evanston, Ill, for Central Scientific Co, instrument incorporates such standard components as dial gage, switch, knob, jacks and handle within a simple, easy-to-form sheetmetal shell. Considering that whoever buys this sort of equipment is more than likely to know what it is for and would only refer to maker's name infrequently, labeling could have been less prominent.

**TO ACHIEVE MINIMUM HEIGHT** and a low center of gravity, cast aluminum frame doubles as front housing in this ride-on mower and rider is positioned forward of motor, rather than astride it. Steering handle tilts forward to ease mounting and for walk-along guidance under low branches. Shroud over engine and rear wheel assembly is a one-piece fiberglass reinforced molding. Minimum ground clearance, ideal in a mower, may prove a problem when this machine is used as a tractor to haul various attachments available for use with it. Made by Porter Cable Machine Co. Instrument design consultant: Arthur J. Pulos, Syracuse, NY.

# MASTER GEARMOTORS

## save material, space and money



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Particularly suited to low speed applications, this Master Gearmotor gives you a highly efficient, self-contained unit that saves you money in a lot of ways:

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4. No separate components—just one compact unit.
5. No high speed coupling, or gear and motor alignment.

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Ratings are from ⅛ to 125 hp.; reduction ratios up to 120:1. You get a maximum choice of mountings: vertical, horizontal or flange; fluid couplings are available for hard-to-start or cycling loads.

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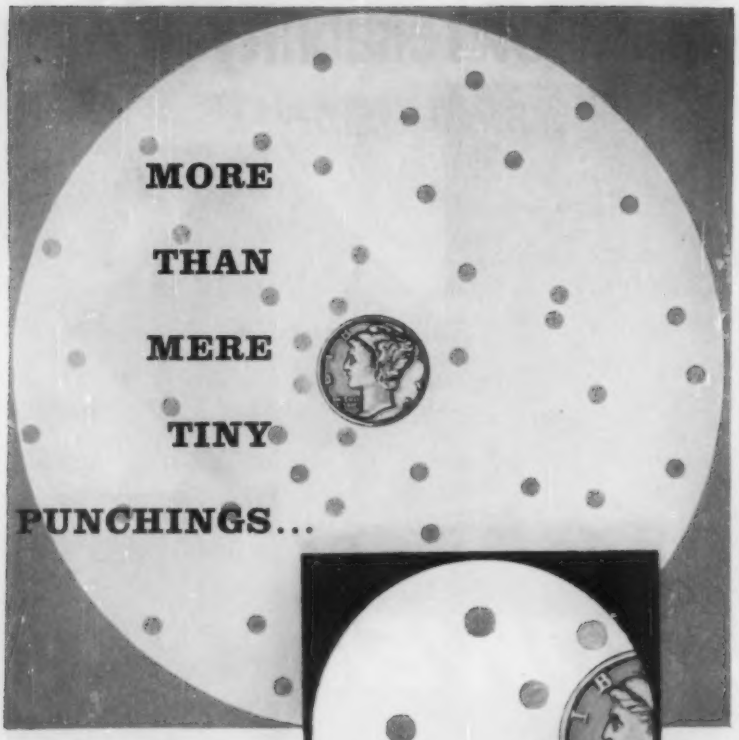


- Specs Nos. 1, 2 and 3 were routine.
- **Specs Nos. 4 and 5 were "unusual".**

What you are looking at are specimen holders for an electronic microscope. They're so small that it takes about 40 to cover a dime. Specifications as to kind of metal, diameter of wire and mesh might be considered routine. It's what we did with the cloth before punching and how we treated the punchings that are important. Spec No. 4 especially tested our manufacturing skills. No. 5 called for special cleaning.

We started with NEWARK Stainless Steel 200 x 200 Mesh Cloth woven with 0.0021 inch diameter wire. Cloth thickness was 0.0042 inches. Then we rolled or calendered the cloth very carefully to 0.0025 inch thickness. After clean-cut punching, we cleaned and passivated the pieces in dilute nitric acid, imparting to them an almost surgical cleanliness...a cleanliness which was retained through the packing. The discs had to be kept free of foreign matter.

As pointed out above, the cloth itself is not uncommon but the rolling and treatment were somewhat unusual. The skill in handling and quality of work typified by this job suggests the skill and quality of work available to you for any "wire cloth" insert project you have in mind. Incidentally, much of our work is in preparing "punchings" in all diameters in single pieces, in segments, or in sectors.

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## READER TO EDITOR

### Fold For Quick Reference

*To the Editor:*

Here is a method of marking magazine pages that may be of interest to your readers. These photos illustrate how a page may be folded to produce a finger tab at the top or bottom of a magazine.

—PHILIP N. WELCH
*Machine Designer,*
*Comparator Div*
*Jones & Lamson Machine Co*

### Rolling Surfaces—Addendum

*To the Editor:*

In the Reader to Editor section of your June 13 issue, C. F. Walton comments on my article, "Wear Life of Rolling Surfaces" (May 9, p 46). The points he makes are well taken and fairly stated. In Chapter Five, Art XII, of the 1957 Gray Iron Castings Handbook, I note that —even though rolling wear is mentioned as a differentiated type of wear—very little discussion is contained on the subject. (Incidentally I have found the handbook to be a thorough and well-balanced source book on the subject of cast iron.) From

all I can discover on the subject of rolling wear the basic mechanism of failure is still little understood. This lack of understanding has prompted the ASME, "to call upon American industry to support a basic research study aimed at discovering why machine parts break down"—with special emphasis upon contact fatigue in rolling elements. I think that for the designer of machines (where motion contact between elements is almost inevitable and perhaps the essentially distinguishing feature of a machine, from a structural viewpoint) basic understanding of contact fatigue is necessary and will be achieved.

In the meantime, the designer is faced with the problem of designing machines that must transmit motion by rolling and sliding contact. He can do this in one of at least two ways. He can resort to past experience and use "trade design factors" that have been accumulated by each industry dealing in the separate machine members (such as ballbearings, gears, etc.) or he can approach the problem by combining understanding of underlying elements common to all machine members—such as geometrical relations, and phenomenological properties of materials. The work of Earle Buckingham and G. J. Talbourdet has pioneered the latter approach with respect to wear resulting from rolling contact. My article serves simply to draw attention to the approach and to emphasize the breadth of application—by citing several examples. I think that the depth of perception of the problem on the part of Buckingham and Talbourdet is to be admired—for by their approach to separating the phenomenological behavior of the material from the geometry—they eliminate with their simple and neat test the problems of basic failure mechanism which are still not understood.

I think everyone concerned looks with approval and with a great deal of interest towards all efforts that are made to acquiring a better understanding of the mechanisms of materials failure.

—Donald J Myatt
*Associate Professor of Engineering*
*Antioch College*

## COMING EVENTS

### AUGUST

**1-3** . . . . Institute of Radio Engineers, 4th Global Communications Symposium, Statler-Hilton Hotel, Washington, DC

**28-Sept 1** . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo

### SEPTEMBER

**6-16** . . . National Machine Tool Builders Association, Production Engineering Show, International Amphitheater, Chicago

**7-9** . . . . American Society of Mechanical Engineers jointly with AIChE, AIEE, IRE, and ISA; Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass


NEEDED: EFFECTIVE VIBRATION ISOLATION AT TEMPERATURE EXTREMES

Vibration-sensitive equipment in high performance missiles and aircraft often poses a two-pronged problem to design engineers: effective isolation against destructive shock and vibration—*at temperature extremes.*

ANSWER: MB'S NEW BROAD TEMPERATURE METAL ISO-DAMP (tm) MOUNT

MB's new broad temperature Iso-Damp mount consists of two load carrying springs, mounted in opposed position, with built-in damper assembly to restrict resonant build-up. It requires no external cooling, can be used at temperatures from −100°F. to +500°F.

WHAT'S YOUR MOUNT PROBLEM?

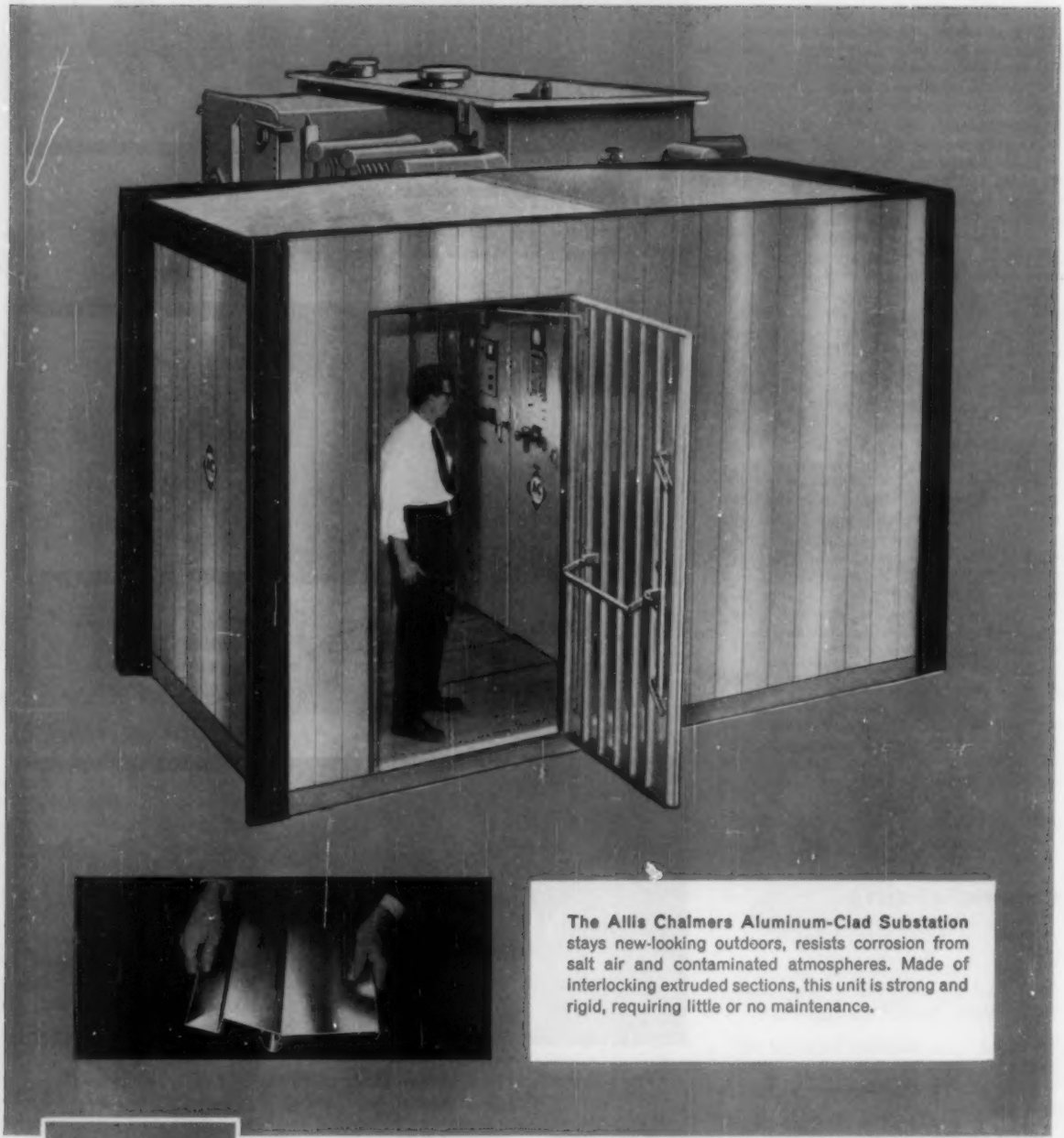
These new mounts can be adapted easily to the isolation of other special equipment as well. Or, perhaps one of MB's many other mount designs may be the answer to your particular vibration control problem. MB has not only the mounts, but also the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

**MB ELECTRONICS**
A DIVISION OF TEXTRON ELECTRONICS, INC.
1076 State Street, New Haven 11, Conn.




CIRCLE 29 ON READER SERVICE CARD 

# How Aluminum Improves Electrical





**The Allis Chalmers Aluminum-Clad Substation** stays new-looking outdoors, resists corrosion from salt air and contaminated atmospheres. Made of interlocking extruded sections, this unit is strong and rigid, requiring little or no maintenance.

## REYNOLDS ALUMINUM

Watch Reynolds TV Shows: "Bourbon Street Beat" and "Adventures in Paradise", and, resuming in October, "All-Star Golf"—ABC-TV

# Equipment and Reduces Costs

- **low cost**
- **weather resistance**
- **high conductivity**
- **workability**

Aluminum is finding greater and greater acceptance as a material for electrical equipment in both structural and conductor uses. It is performing these jobs more efficiently, and in many cases, at a much lower total cost than the materials it replaces.

### PROTECTS ELECTRICAL EQUIPMENT AND CONDUCTORS

Aluminum equipment panels and structural members resist weathering and corrosion; they never rust; they need no painting or protective coatings. As a result, equipment made with Reynolds Aluminum requires less maintenance and protection.

And panels can be fabricated quickly and economically because aluminum is easy to machine and form. Easy to cut, easy to extrude, easy to bend and shape, aluminum holds production costs to a minimum.

### DESIGN FLEXIBILITY WITH ALUMINUM CONDUCTORS

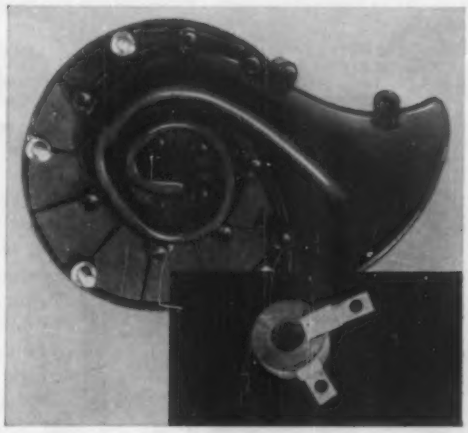
Aluminum strip conductor, a comparatively new development, was pioneered by Reynolds several years ago. Anodized strip is often used in transformers, magnetic clutches and brakes. The anodized film provides the insulation for a completely self-contained and compact circuit. Interleaved foil conductor can replace wire coils, providing equal conductivity at lower cost, higher dielectric strength, fewer "hot spots," and simplified manufacturing. The customer can select his own interleaving material. Reynolds Aluminum strip conductor can simplify product and circuit design, save space and weight.

### ALUMINUM BUS CONDUCTOR

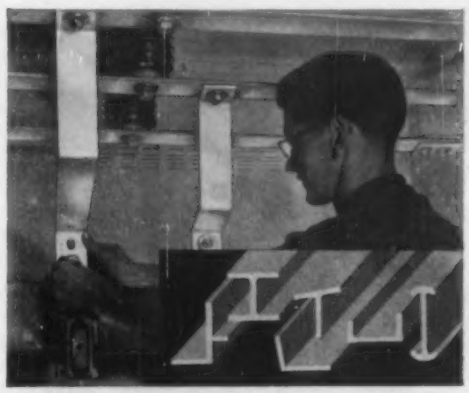
Reynolds Aluminum bus bar, available bare or silver plated, offers an important price advantage over comparable conductors. Aluminum bus bars are available in a wide range of shapes and sizes to meet virtually any design requirement. Silver plated bus bar simplifies soldering, and permits higher operating temperatures with bolted joints.

These are just a few examples of how Reynolds Aluminum is used to improve electrical equipment, and to reduce costs.

For technical data and details on the properties of aluminum, call your local Reynolds office, or write *Reynolds Metals Company, P.O. Box 2346-HN, Richmond 18, Virginia.*



**Sparton Automotive** eliminated eleven parts in automobile horn coils by using Reynolds Aluminum strip conductor. Higher dielectric strength was possible because of the interleaving material that could be used. Turn-to-turn voltage breakdown was reduced. The magnetic lines of flux were more uniform. Heat dissipation was improved, hot spots were eliminated.



**S & C Metalclad Switchgear** uses Reynolds Aluminum Silver Plated Bus Bar. Space requirements were met with silver plated bus bar, and production was greatly simplified. Easily sawed, punched and formed without peeling or chipping, silver plated bus bar is lower in cost and much lighter in weight than equivalent copper bar. It requires no prior preparation, and meets all electrical code standards.

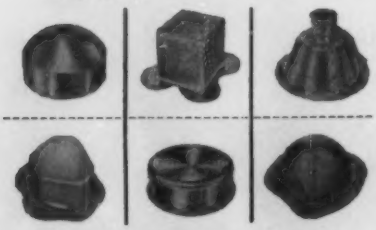


CIRCLE 31 ON READER SERVICE CARD

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

**Hydroforming, Deep Drawing and Spinning**

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

**C. B. KAUPP & SONS**

*Metal Craftsmen since 1924*

NEWARK WAY, MAPLEWOOD, N. J.
Telephone: SOuth Orange 3-2490

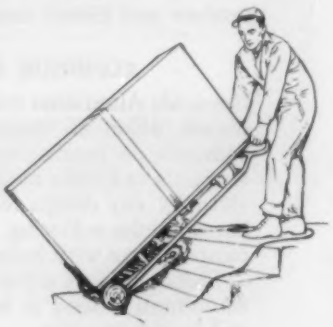

# WHY DON'T THEY R&D..?

. . . a stair-climbing wheelchair. A national contest, sponsored jointly by the President's Committee on the Employment of the Physically Handicapped and the National Inventors Council, offers a prize of $5000 to the inventor who develops a wheelchair that allows handicapped persons to get around industrial plants unaided. The aim of the development is to promote employment of persons who, although capable of doing many industrial jobs, are presently limited because they cannot get to and from their place of work without help from an attendant.

The wheelchair should be made so that the occupant can negotiate stairs that have average-height risers and variable tread depth. It should also be able to turn on any stair landing large enough for the chair to maneuver. It is preferred that stair-climbing be achieved under the occupant's own power although it may be necessary that an attendant steady the chair while it is tilted for climbing. In such a case, it must be balanced so that no more than 15 or 25 lbs is transferred to the attendant. In descent, it can be made to back down if it is not feasible to descend with occupant facing down stairs. Speed of ascent and descent is not critical but should be a reasonable rate.

Contest rules specify that the chair be "self-propelled" (which we interpret to mean "powered by the occupant"—electric motors and self-contained batteries would probably be too bulky and too expensive). Effective arm-strength of occupants is estimated at a minimum of 10 lbs. The chair must also meet the following requirements: weight, no more than 50 to 75 lbs; sturdy enough for a 200-lb occupant; collapsible so that it can be folded and stowed in an automobile by the user; cost no more than $500 (current models of self-propelled tubular-frame folding wheelchairs cost approximately $150).

Proposed designs for the wheelchair should be sent to National Inventors Council, US Department of Commerce, Washington 25, DC. The council will screen all ideas and present the best to three judges who will choose the one they feel to be most practical and workable. Submission of an idea does not transfer title to the government but it does imply that the contest winner will not use his proprietary rights to impede commercial introduction of the device. If no single device satisfies the requirements, the judges reserve the right to grant lesser prizes to several inventors and combine these ideas in one design. The $5000 prize has been donated by a private citizen. The sketch at right shows a recently developed hand truck that climbs stairs on a pair of wide rubber tracks. The tracks are driven by an electric motor powered from a convenient electric outlet. Although this design is not an appropriate solution to the wheelchair problem, some of the principles might well apply.

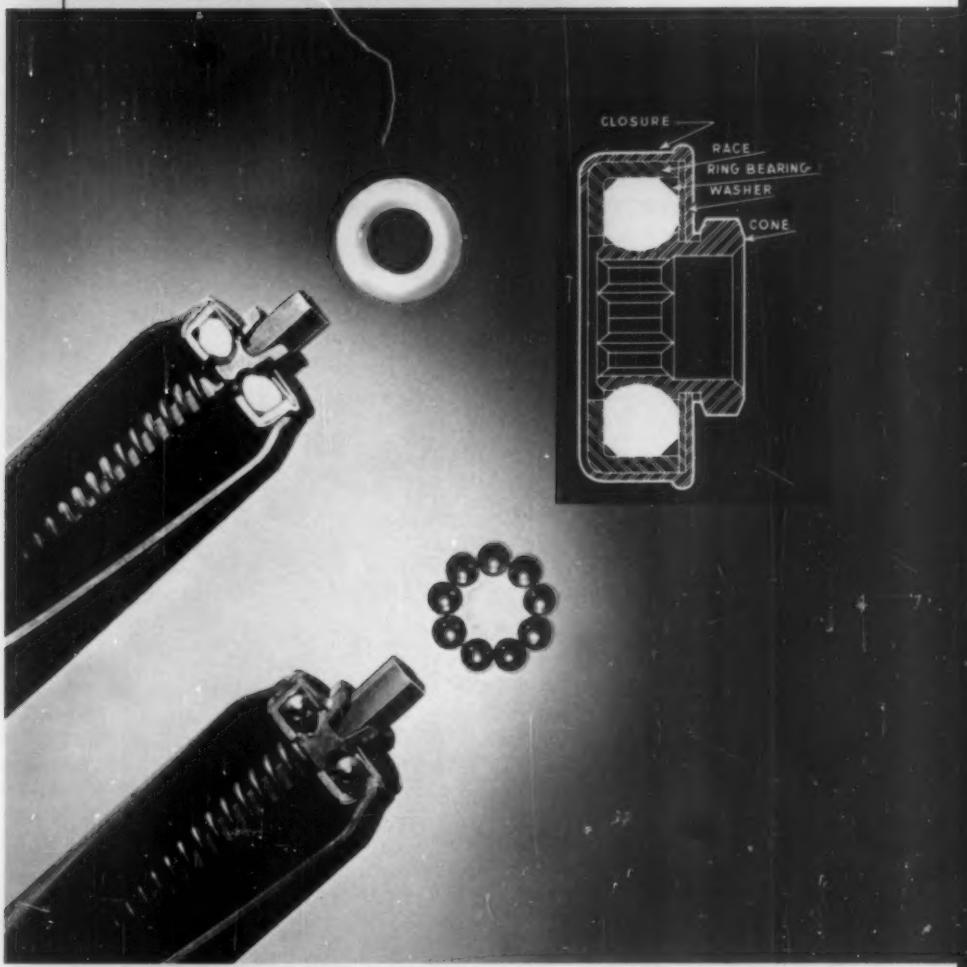


**Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.**

*working with*

# Du Pont Delrin®

*one of Du Pont's versatile engineering materials*




*Ring bearings molded by Sinko Tool and Manufacturing Co., Chicago.*

## Ring bearing illustrates why Delrin® is doing so many jobs once reserved for metals

The use of roller and wheel conveyors in manufacturing, wholesale and retail business has become commonplace today. But as universal as their use is, they have remained relatively noisy mechanisms.

This objection prompted the Rapids-Standard Co., Inc., Grand Rapids, Mich., to seek a new material to replace the steel balls in the bearings of their conveyors. Their choice was rings of "Delrin" acetal resin (roller conveyor shown above). With "Delrin", the conveyors are now "virtually noiseless". The bearings require no lubrication in service, and they will not corrode in normal use. In addition, weight savings of 50-65% have been realized.

This ability of "Delrin" to compete with steel, die-cast zinc and aluminum, cast and machined brass, and cast iron (see reverse side for additional examples) stems from its unique combination of physical properties and design-production economies. With "Delrin", manufacturers are discovering new ways to improve product performance—often at lower cost.

• • •

We will welcome the opportunity to assist you in evaluating how "Delrin" can bring these advantages to your products. A coupon appears on the reverse side for your convenience.

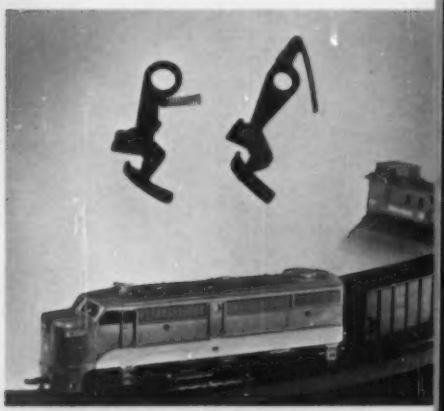
DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

*working with*

# Du Pont Delrin®

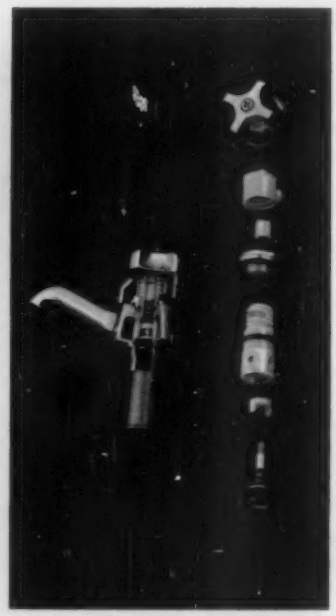
*one of Du Pont's versatile engineering materials*

## These typical end-uses reveal performance and cost advantages of Delrin®



The Lionel Corporation, Irvington, N. J., recently introduced a new HO train line featuring a one-piece coupler molded of "Delrin". Because "Delrin" has the resilience to provide the desired springing action, Lionel designed the integral unit to replace a two-part assembly of coupler and coil spring. The result: a significant assembly saving plus a new sales feature. "Delrin" is also used for the axles, journals and two other truck parts. (Molded by Lionel and Gries Reproducer Corp., New Rochelle, New York.)

The head frame (top) of the new "Lady Ronson" Superbe electric shaver is molded of "Delrin", saving 80% of the weight of the previous gold-plated die-cast zinc part. Ronson Electric Shaver Corp., Stamford, Conn., specified "Delrin" because it could be molded to and hold the necessary dimensions, have a smooth luster without finishing and resist body oils and colognes.



Four parts (in white) of this self-seating faucet are molded of "Delrin", saving 80% of the cost of the machined brass components formerly used by the Kel-Win Manufacturing Co., Inc., Richmond, Va. Kel-Win chose "Delrin" because it resists corrosion and mineral buildup, remains dimensionally stable and eliminates machining operations and rejects. (Molded by Dominion Plastics Co., Colonial Heights, Virginia.)

"Delrin" acetal resin offers designers such properties as strength, stiffness, dimensional stability, resilience and abrasion resistance; and it retains these properties even under exposure to wide variations in temperature, humidity, solvents and stress. Already hundreds of designs taking advantage of these properties, and of the cost savings made possible by rapid injection molding, have been specified or put into commercial production. We suggest that you investigate how "Delrin" can be profitably used in the products you make and the products you use. Commercial processors and our own staff of technologists are ready to assist you.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Department 134 Room 2507-D
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

_____

*Name*_____

*Company*_____ *Position*_____

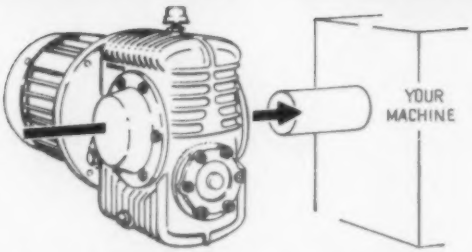
*Street*_____

*City*_____ *State*_____

**DELRIN®** *acetal resi*

Alathon® · Zytel® · Lucit

# CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER




***Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .***

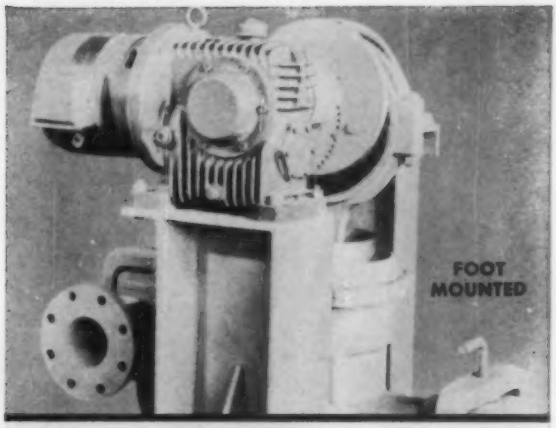
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

**CONE-DRIVE GEARS**
**DIVISION MICHIGAN TOOL COMPANY**
*7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111*

DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



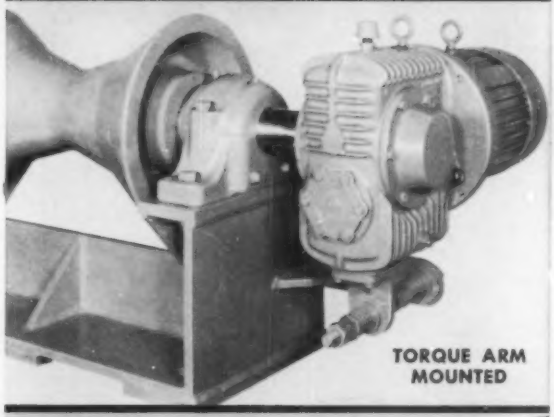



Illustration of Malleable casting being turned at 1,400 surface feet per minute with a 0.100" depth of cut using an oxide tool.

## Cut Machining Time and Costs... Use Malleable

It's the **finished** cost of machined components that's important to you. Remember then . . . Malleable iron is the most readily machinable of all ferrous metals of similar properties. With Malleable castings you'll reduce machining time as much as 50% . . . increase tool life up to 250% . . . get unexcelled surface finishes.

Find out how much you can cut **your** finished parts costs. Contact any nearby Malleable castings producer who displays this symbol—

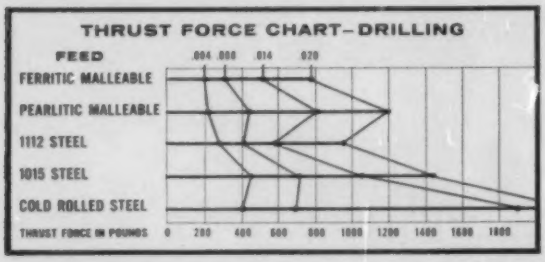
MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Machinability of Malleable Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

# You'll Get Faster Machining...Better Finished Surfaces... Longer Tool Life with Malleable Castings

Whatever your machining goals—reduced cycle times, lower tool costs or better surface finishes, you will profit from remembering this fact: Malleable is the most machinable of all ferrous metals of comparable properties.

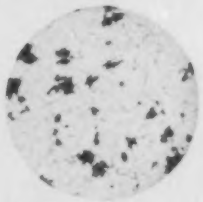
For example, compare the force required to drill Malleable with that required to drill other commonly used metals as we have done here—



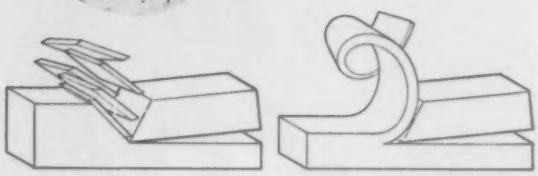

For this test we used ½ inch high speed steel twist drills with a suitable lubricant and a spindle speed of 715 RPM. AISI 1112 steel (Bessemer screw stock) was included because it is often used as a standard for machinability comparisons. Since machining may cost 2 to 4 times as much as the rough parts, the superior machinability of Malleable iron, as demonstrated here, can result in very large savings.

## Chips Reveal the Secret of Malleable's Machinability

In addition to providing strength and ductility, Malleable's internal structure of microscopic carbon nodules allows Malleable to break easily into small chips as it is machined. This kind of Type I chip is highly desirable. Speeds and feeds can be increased . . . power consumption drops . . . cutting tools last longer. Malleable's uniform structure permits safe machining at maximum speeds.



Spherical carbon nodules (black) help break up chips. Photomicrograph 50X, etched.



Schematic drawing illustrates how Malleable (left) breaks into short, discontinuous Type I chips, rather than long, continuous Type II and III chips (right).

## Future Promises New Triumphs for Malleable

With over two years' experience in advanced machining research, forward-looking Malleable castings producers already know how Malleable will perform when oxide cutting tools come into wide use. In experiments like the one illustrated on the opposite page it has been demonstrated that Malleable can be successfully machined at speeds as high as 1400 surface feet per minute and a 0.100" depth of cut! Surface finish, tool life and metallurgical structure are excellent . . . All this in a metal of rugged engineering properties.

Prove for yourself how much Malleable's machinability will do for your products . . . and your profits. Get in touch with one of the Malleable castings producers listed below. Call today.

**Send for Free Machining Information** —A special folder, *Data Unit 106, Machining Malleable Iron Castings,* is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.

## For Quality and Economy...Use MALLEABLE

**For Service In Your Area Contact...**

**CONNECTICUT**
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

**DELAWARE**
Eastern Malleable Iron Co., Wilmington 99

**ILLINOIS**
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

**INDIANA**
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

**IOWA**
Iowa Malleable Iron Co., Fairfield

**MASSACHUSETTS**
Belcher Malleable Iron Co., Easton

**MICHIGAN**
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

**MINNESOTA**
Northern Malleable Iron Co., St. Paul 6

**MISSISSIPPI**
Mississippi Malleable Iron Co., Meridian

**NEW HAMPSHIRE**
Laconia Malleable Iron Co., Laconia

**NEW YORK**
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

**OHIO**
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

**PENNSYLVANIA**
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

**TEXAS**
Texas Foundries, Inc., Lufkin

**WEST VIRGINIA**
West Virginia Mall. Iron Co., Point Pleasant

**WISCONSIN**
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

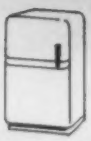
CIRCLE 37 ON READER SERVICE CARD

(Inland "job-tailored" Cold Rolled Sheets)

# FORMABILITY

Like the supple bending . . . the creation of new shapes and forms by this highly-trained dancer . . . steel, too, must be endowed with similar ability . . . FORMABILITY. If it is to meet the varied needs of today's manufacturing practices, steel must be produced for ease of fabrication . . . must form dependably without springback or surface disturbances.

FORMABILITY, as a working characteristic, is carefully built into Inland Cold Rolled Sheets. Prime consideration is the use for which the steel is ordered. Inland makes certain it *knows* its customer's requirements . . . works always to satisfy such specific needs.



In Yoder forming and tangent bending of refrigerator wrappers, Inland Cold Rolled Sheets do not flute (panel) or spring back.

Television cabinet wrappers are not marred by surface disturbances even though Inland Sheets are brake press formed on fast assembly lines.

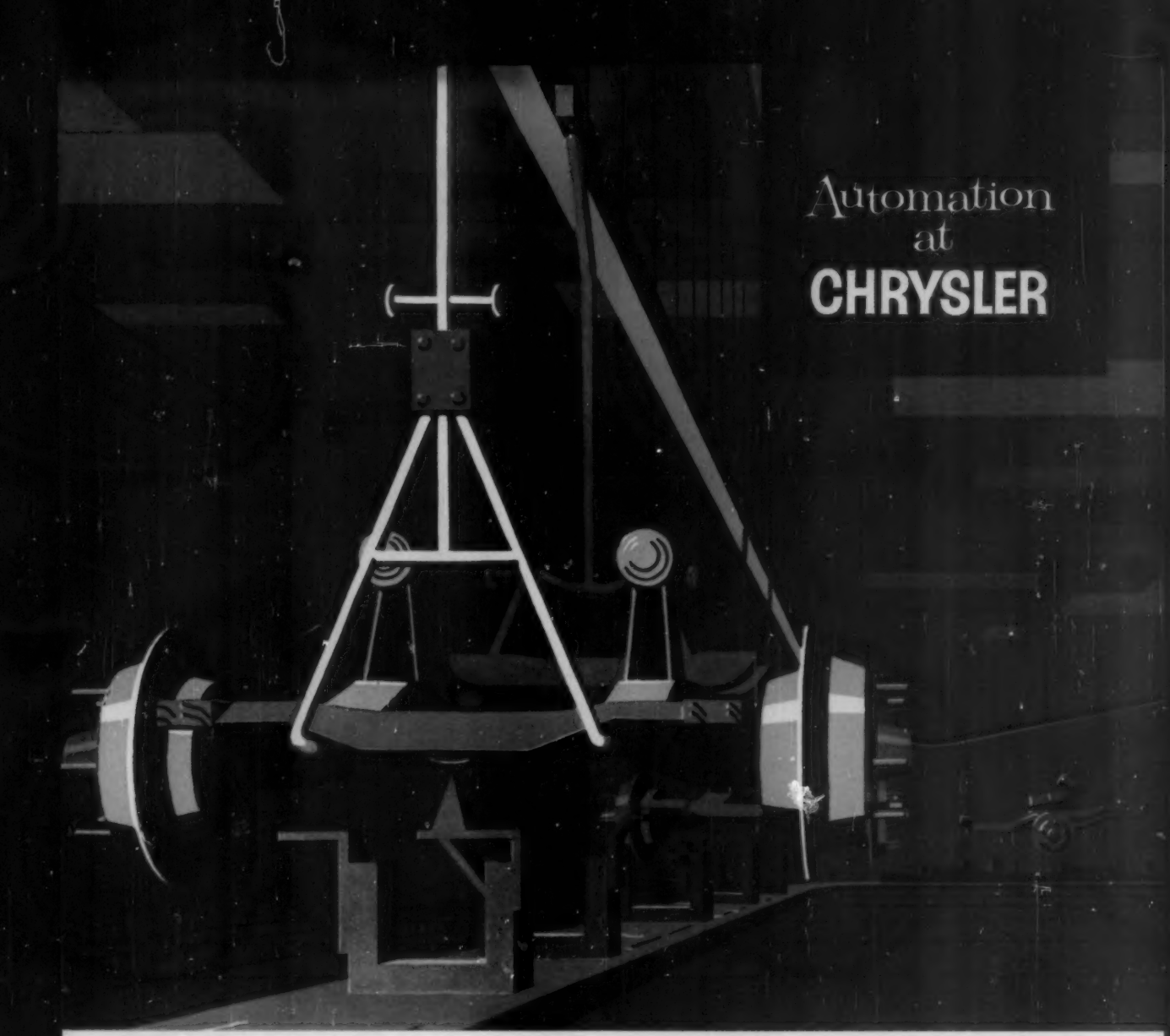
Projection screen cases are produced with Inland Sheets without time-wasting springback and with no fluting to mar attractive appearance.

INLAND

**INLAND STEEL**

**30 West Monroe St., Chicago 3, Ill.**

Sales Offices: Chicago • Davenport • Detroit Houston • Indianapolis • Kansas City • Milwaukee • New York • St. Louis • St. Paul




# VARIDYNE a/c drive system synchronizes assembly conveyors

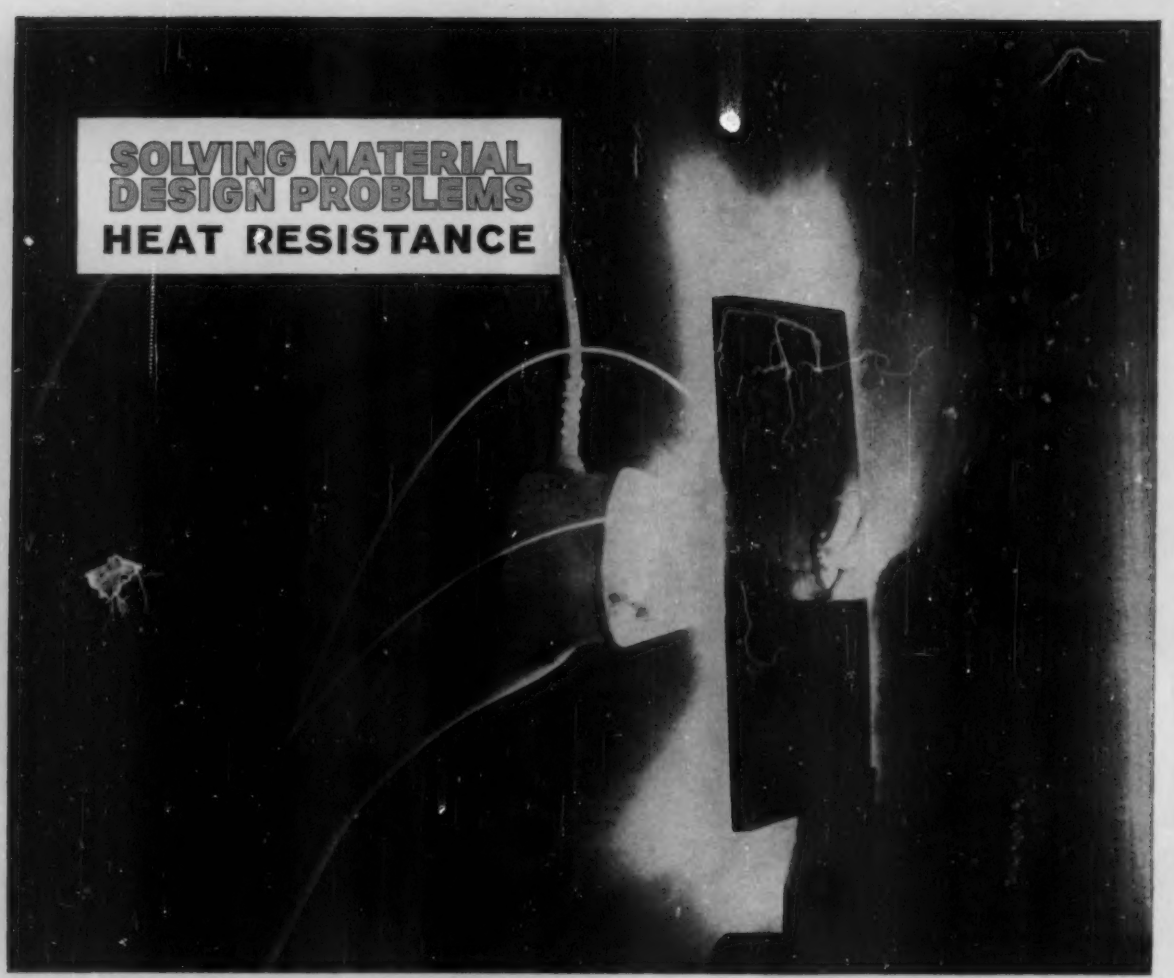
**Problem:** Chrysler Corp., Dodge Division, new unitized body assembly lines required linkage of three *variable-speed, continuous motion* conveyors—stub frame overhead, main assembly pedestal and final assembly flattop. At transfer point, shown above, pin in conveyor must match hole in frame with no cumulative error.

**Solution:** U.S. VARIDYNE a/c Drive System with *LinkSync* control. Chrysler engineers working with U.S. Motors field engineers chose VARIDYNE over a d.c. system because: initial start-up is simplified; instantly synchronous without warm-up; needs no synchronizing readjustments; there is no cumulative error; and maximum reliability is assured by use of *standard a.c. motors.* VARIDYNE varies the frequency of a.c. current to these motors, converting them to adjustable speeds. *Write today for* VARIDYNE *Brochure F-1963.*

**U.S. ELECTRICAL MOTORS INC.**

P. O. Box 2058, Los Angeles, California or Milford, Connecticut

CIRCLE 39 ON READER SERVICE CARD




**A 5000° flame** takes ten minutes to penetrate a one-quarter inch piece of CDF's new Dilecto RD-105 laminate. The same thickness of cold-rolled steel is pierced in less than forty seconds.

Molded from graphite fabric impregnated with a heat (ablation)-resistant phenolic resin, new CDF grades RD-105 and RD-115 are being evaluated in solid propellant rocket motors.

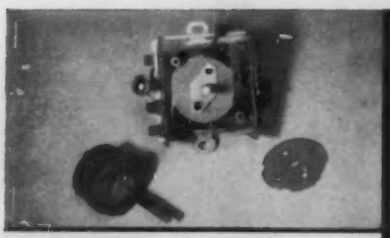
Dilecto laminates are only one family of products from industry's largest selection of non-metallic structural materials and electrical insulations. Vulcanized fibre, silicone rubber and mica, and thermosetting moldings are also supplied by CDF.

CDF can provide both quality and true economy in selecting plastic materials best suited to your needs. Refer to SWEETS PD file or write to us for General Folder 60.

## CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bruhl COMPANY • NEWARK 40, DEL.

In Canada, 46 Hollinger Road, Toronto 16, Ont.



**Moisture-resistant** and low cost Dilecto cams for automatic washer and dryer controls.

**Dimensionally stable,** light weight, oil-resistant Dilecto ball bearing retainer rings.

**Easily fabricated** paper-base, punching grade Dilecto precision switch insulators.

# AGAIN-

Shown here is the 6" Rapidaire Dolphin Submersible Pump, one of a complete line of 4" and 6" pumps made by THE TAIT MANUFACTURING COMPANY, Dayton, Ohio. Arrow points to the upper body shell made of Revere seamless leaded brass tubing. Hand holds the diffuser casing made of Revere Brass Strip and used inside pump.

# Revere helps "fit the metal to the job"

## AND A PUMP MANUFACTURER FABRICATES SUPERIOR PARTS WITH GREATER EASE . . . INCREASES TOOL LIFE

An important part of the submersible pumps made by Tait Manufacturing Company is the brass diffuser casing you see above. This part had formerly been made of ferrous metal. While satisfactory as a pump part it was difficult to work and draw . . . at the same time tool life was short.

One of Revere's Technical Advisors was asked to study the problem. Revere Cartridge Brass Strip of a certain temper was recommended, samples submitted, and, after extensive tests, was approved. The customer has found that not only does the diffuser casing, made of Revere Brass, perform well in the pump, but it also has superior drawing properties, is more easily worked, and tool life has been substantially increased.

This meticulous attention to "fitting the metal to the job" also resulted in Tait Manufacturing Company's specifying Revere seamless leaded brass tubing for the upper body shell of its submersible pumps. Here the application called for extremely close straightness and roundness control which meant special attention to detail on the part of the Revere mills.

Why not put the extensive knowledge of Revere's T.A. Service to work for you? With the wide variety of metals at your disposal, perhaps Revere can help you select the one best suited for the job, with a resultant saving of money while improving product quality.

**REVERE COPPER AND BRASS INCORPORATED**

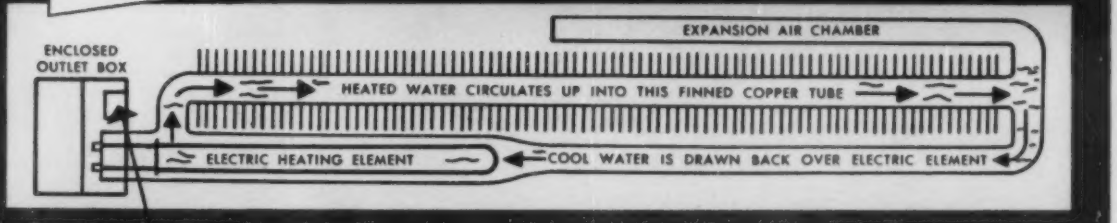
*Founded by Paul Revere in 1801*

**Executive Offices; 230 Park Avenue, New York 17, N. Y.**

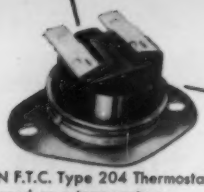
*Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Fort Calhoun, Neb.*
*Sales Offices in Principal Cities, Distributors Everywhere.*

# INTERNATIONAL Chooses KLIXON Snap-Acting Thermostats...

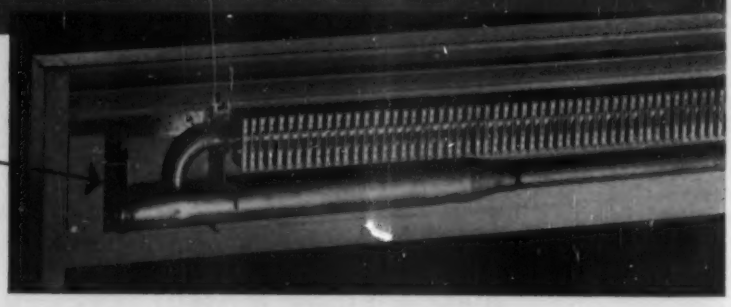
## For accurate, dependable control, ease of application, low cost in their Hot Water Electric Baseboard Heaters.


EXPANSION AIR CHAMBER
ENCLOSED OUTLET BOX
HEATED WATER CIRCULATES UP INTO THIS FINNED COPPER TUBE
ELECTRIC HEATING ELEMENT
COOL WATER IS DRAWN BACK OVER ELECTRIC ELEMENT

Schematic drawing showing liquid flow in International's Electric Baseboard Heater.



KLIXON F.T.C. Type 204 Thermostat used as a temperature limit control.



The International electric baseboard heater utilizes circulating liquid in a self-contained system.

In developing these heaters, International Oil Burner Co., Electric Heat Division, 3800 Park Ave., St. Louis, Mo., chose KLIXON type 204 Thermostats to provide operating temperature limitation at the optimum level.

International also uses KLIXON Snap-Acting Thermostats in many other well known types of heating equipment.

There are good reasons why leading original equipment manufacturers choose KLIXON Thermostats.

First and foremost, KLIXON Thermostats insure accurate temperature control according to "specs". Next, the dependable performance of KLIXON Thermostats means trouble-free service. Switch action is clean and unaffected by mounting position even when subjected to shock and vibration. Accurate fixed temperature settings calibrated at the factory prevent tampering by unauthorized persons.

M & C Field Engineers will gladly help you make test applications of KLIXON Controls at your request. Send for technical data bulletins on KLIXON Commercial Thermostats and get acquainted with the low cost applications possibilities on your products. No obligation, of course.

**TEXAS INSTRUMENTS**
**INCORPORATED**
METALS & CONTROLS DIVISION
3907 NORTH MAIN ST. • VERSAILLES, KENTUCKY

Spencer Products: Commercial Controls Department

**The American Brass Company**
**Waterbury 20, Conn.**

Please send me a copy of your 8-page booklet which details properties of your four free-cutting, high-conductivity coppers, and suggested machining practices.



Name.....

Company.....

Street.....

City.....Zone.....State.....

# 4 ways to cut the cost of high-conductivity parts

**There are now four free-cutting,** high-conductivity Anaconda coppers that broaden the combinations of mechanical, physical, and fabricating properties available for boosting production and cutting costs of high-conductivity parts. They are furnished chiefly in rod and bar, but are available also as extruded shapes and, except for the leaded coppers, die-pressed forgings of simple design. All have good cold-working properties.

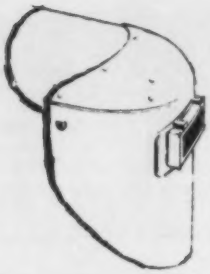
**Leaded Copper-126 and Deoxidized Leaded Copper-129** have slightly higher electrical conductivity—98% IACS annealed, 95% IACS, minimum. The difference between them is that Alloy 129, being deoxidized, is not subject to hydrogen embrittlement when annealed or furnace-brazed in reducing atmospheres. Neither leaded alloy is recommended for hot working.

**Tellurium Copper-127 and OFHC Sulfur Copper** have an electrical conductivity rating of 95% IACS annealed, 90% minimum. Both may be extensively hot worked and neither is subject to hydrogen embrittlement. Tellurium Copper-127 has the advantage of retaining its mechanical properties at temperatures higher than those tolerated by the other free-cutting coppers—and hence is widely used in the welding and cutting-tip field.

The free-cutting coppers may be machined at cutting speeds approaching those used for machining Free-Cutting Brass. For Tellurium Copper-127, however, carbide-tipped tools are recommended as the inherent copper telluride particles cause somewhat greater tool wear.

6047

**ANACONDA®**
**FREE-CUTTING HIGH-CONDUCTIVITY COPPER PRODUCTS**
*Made by The American Brass Company*



NO. 7 OF A SERIES

**"How to Design Welded Aluminum Structures"**

# New Design Specifications for Welded

**Mr. Harry N. Hill,** *Engineering Design Division Chief, Alcoa Research Laboratories, Aluminum Company of America, reports findings presented at the 1959 annual meeting of the American Society of Civil Engineers.*

New recommended design rules for a number of the more important aluminum alloys being welded today have been prepared by Alcoa. These rules are based on the results of continuing investigations at the Alcoa Research Laboratories and have led to the new concepts of strength of welded aluminum that have been discussed in previous articles in this series.

While *complete* design rules are not possible in this space, the table at right lists the recommended basic allowable stresses for some of the most important alloys and tempers. (Complete rules for welded structures of 5456-H321 were presented at the 1959 annual ASCE meeting. Free copies available from Alcoa on request.) Values are for the types of structures that would be designed in steel according to AREA, AASHO or similar specifications. Allowable stresses would be about 12 per cent higher when designing structures such as those done in steel according to AISC or similar specifications. Allowable stresses *can*, of course, be adjusted to *any* desired safety factor.

The recommended allowable stresses are based on minimum mechanical properties and conservative values of minimum expected weld strength, as discussed in earlier articles in this series. Higher allowable stresses may be justified where a given welding technique gives consistently higher weld strengths.

A brief examination of the table reveals that the evaluation of the allowable stress expressions requires only the simplest arithmetic. Nomographs, such as Fig. 1 for alloy 6061-T6, make such evaluation even easier.

Allowable stresses given in the table for compression, and for shear in plates and webs, are for cases in which buckling is not involved. If strength is controlled by buckling, allowable design stresses are obtained from families of curves such as those shown in Fig. 2 for welded 6061-T6 columns and beams. Similar Alcoa charts give design stresses for buckling of plates and webs.

The final article of this series will discuss the fatigue strength of welded joints in aluminum alloys.

For top-quality aluminum welding products such as consumable electrodes, welding and brazing rods and fluxes, and solder and soldering fluxes, contact your nearest Alcoa sales office. For complete information on "Designing Welded Aluminum Structures," write Aluminum Company of America, 1760-G Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

WELDING MATERIALS

# Developed by Alcoa Aluminum Alloy Structures

## Recommended Allowable Stresses for Welded Aluminum Structures

Factor of Safety on Yielding=1.85
Factor of Safety on Ultimate Strength=2.20
Stresses are in kips per square inch

| Alloy and Temper | Filler Alloy | Product | TENSION | COMPRESSION | SHEAR | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | (Plates and Webs)† | | Fillet Welds | |
| | | | Beams and Members Under Axial Load | (Beams and Members) (Under Axial Load)† | Welded | Not Welded | Longi-tudinal | Transverse (Symmetrical) |
| 5456-H321 | 5556 | Sheet and Plate | $17.8-7.6\frac{A_{rt}}{A}-3.8\frac{A_{rt}}{A}$ | $17.2-7.0\frac{A_{rt}}{A}-3.2\frac{A_{rt}}{A}$ | 8.1 | 10.3 | 9.1 | 14.5 |
| 5456-H343 | 5556 | Sheet | $22.2-11.9\frac{A_{rt}}{A}-8.1\frac{A_{rt}}{A}$ | $21.1-10.8\frac{A_{rt}}{A}-7.0\frac{A_{rt}}{A}$ | 8.1 | 13.0 | 9.1 | 14.5 |
| 5456-H311 | 5556 | Extruded Shapes | $13.5-3.2\frac{A_{rt}}{A}-1.1\frac{A_{rt}}{A}$ | $11.9-1.6\frac{A_{rt}}{A}-0.5\frac{A_{rt}}{A}$ | 7.0 | 7.6 | 9.1 | 14.5 |
| 5454-H34 | 5554 | Sheet and Plate | $15.7-9.2\frac{A_{rt}}{A}-7.0\frac{A_{rt}}{A}$ | $14.6-8.1\frac{A_{rt}}{A}-5.9\frac{A_{rt}}{A}$ | 4.9 | 9.2 | 6.4 | 8.6 |
| 5454-H311 | 5554 | Extruded Shapes | $10.8-4.3\frac{A_{rt}}{A}-2.1\frac{A_{rt}}{A}$ | $9.7-3.2\frac{A_{rt}}{A}-1.6\frac{A_{rt}}{A}$ | 4.9 | 5.9 | 6.4 | 8.6 |
| 5086-H34 | 5556 | Sheet and Plate | $18.4-9.8\frac{A_{rt}}{A}-8.1\frac{A_{rt}}{A}$ | $16.8-9.2\frac{A_{rt}}{A}-6.5\frac{A_{rt}}{A}$ | 5.9 | 10.8 | 9.1 | 12.3 |
| 6061-T6 | 5556 | Sheet, Plate, Extruded and Rolled Shapes | $\left[\begin{array}{l}18.9-13.0\frac{A_{rt}}{A}-10.8\frac{A_{rt}}{A}\\ \text{or}\\ 17.3-7.3\frac{A_r}{A}\end{array}\right]^*$ | $18.9-13.0\frac{A_{rt}}{A}-10.8\frac{A_{rt}}{A}$ | 4.9 | 10.8 | 9.1 | 9.1 |

A=Net area of cross section $A_{rt}$=Reduced-strength area of cross section due to longitudinal welds $A_{rt}$=Reduced-strength area due to transverse or localized welds
$A_r=A_{rt}+A_{rt}$

† When strength is not controlled by buckling

* Use whichever value is lower

FIGURE 1

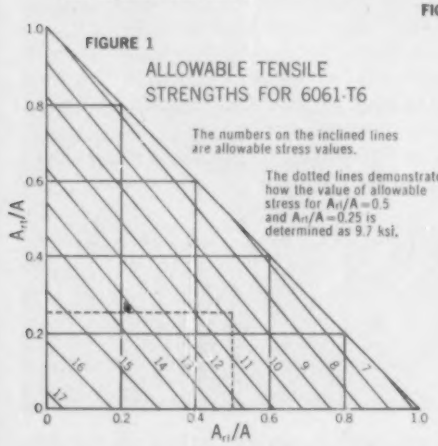
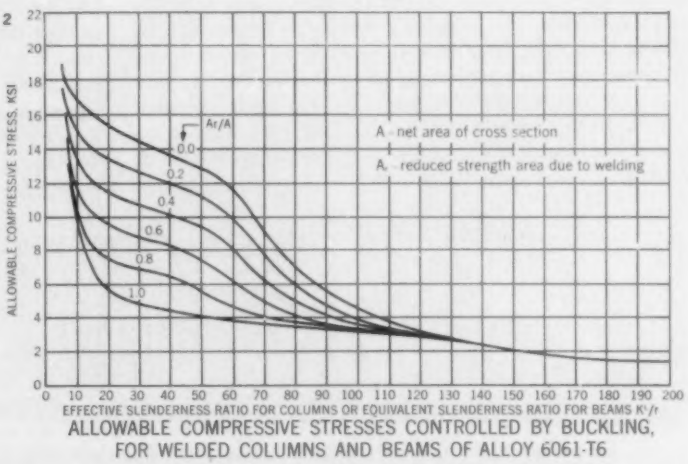



FIGURE 2




ALLOWABLE COMPRESSIVE STRESSES CONTROLLED BY BUCKLING, FOR WELDED COLUMNS AND BEAMS OF ALLOY 6061-T6



CIRCLE 45 ON READER SERVICE CARD

# Twisting, turning application shows...

## how V-belts reinforced with DACRON® POLYESTER FIBER permit greater design freedom

Ask a V-belt to transmit power over four pulleys, with a quarter turn between each. Put it under heavy load, yet limit its width. Demand long service, but permit only minimum stretch, minimum fatigue. Then, depend on it to meet these requirements if it is reinforced with "Dacron"* polyester fiber made by Du Pont—because it will. That's exactly the kind of belt performance required of—and met by—a leading V-belt manufacturer.

When new designs place unusual burdens on V-belt power transmission, turn to V-belts reinforced with Du Pont "Dacron". These belts cut drive costs, permit greater design flexibility, fewer belts or more H.P. per belt. Rely on them also for longer life, greater strength and shock absorbency, excellent dimensional stability.

**FREE BOOKLET:** "Du Pont 'Dacron' Sets New Standards for V-belt Performance". Write E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., 31E Centre Road Bldg., Wilmington 98, Delaware.

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*"Dacron" is Du Pont's registered trademark for its polyester fiber.

Enjoy "The Du Pont Show With June Allyson"—Monday Nights—CBS-TV

# How steel tubing saves weight in helicopter...in budget, too

Shown below is the main rotor shaft of a new model helicopter. Because it was hollowed out of solid steel bars to save weight, it was costly to make. After machining to thousandths of an inch accuracy, previously undetected steel flaws showed up. One out of every five parts had to be rejected.

Timken Company Metallurgists were consulted. After careful study, they recommended a special analysis of Timken® seamless steel tubing. Savings began immediately. Because the hole was already there, no drilling was required. Steel was saved. And with the extra advantage of uniform forged quality in Timken seamless tubing, rejects of finished parts were practically nil.

Let us help you cut your costs, get better quality finished products. Our engineers will recommend the most economical tube size for your hollow parts jobs, one guaranteed to clean up to your finish dimensions. ***When you buy Timken Steel you get:*** *1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Personal attention from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

DOW

**NEWS ABOUT PRODUCT DESIGN AND MATERIALS**

*From the technical development laboratories at Dow comes a steady stream of new applications for those versatile materials—the thermoplastics . . . new applications that accent beauty, function, production economy . . . new applications that stimulate ideas for your own designs and processes. The products described on these pages contain just a few of the Dow thermoplastics that are serving today's designers . . .*

# FUNCTIONAL DOW PLASTICS EXTEND PRODUCT DESIGN LIMITS

**Within each broad category of Dow thermoplastics there are often several different formulations designed to pinpoint the functional requirements of designers and processors. Thus, you can select an individual Dow plastic material to extend the limits of your requirements for moldability, durability . . . lightness, inertness . . . beauty, clarity, or color . . .**

One Dow thermoplastic—Tyril®—adds an extra measure of beauty, moldability and physical strength to the design of this modern built-in blender. Mixing, chopping, or liquefying in a matter of seconds, are just a few of its accomplishments.

To ensure its top performance under all forms of kitchen punishment, the designer specified clear Tyril for molding the blending jar. Tyril – a Dow copolymer of styrene and acrylonitrile—gives this appliance part toughness and high shock resistance to withstand the churning action of the high-rpm knife blades . . . its chemical resistance helps the jar stand up under the attacks of food acids and cooking ingredients . . . its temperature resistance protects against cracking or crazing over a wide temperature range—from mixing boiling liquids to crushing ice . . . and excellent moldability enables Tyril to reproduce the jar's complex shape and the finely detailed cup and ounce measuring marks. Washing presents no hazards, either. Detergents won't harm Tyril, nor will hot water, and it withstands normal abuse.

**One of the problems** designers have had to face when insulating a product is compensating for the added bulk and weight of thermal insulation. Today, designers have solved this problem with Pelaspan® – Dow expandable polystyrene in bead or pellet form. Foamed in place by the manufacturer, Pelaspan provides thermal insulation with negligible bulk or weight for this beverage cooler. (opposite page).

Pelaspan beads can be pre-foamed, expanded many times. When a molding or structural cavity is filled with them, and the beads are further expanded by steam, they tightly close up the interstices and make a molding of uniform density. The closed-cell structure created

has low thermal conductivity, low water absorption, low vapor transmission, and a high strength-to-weight ratio.

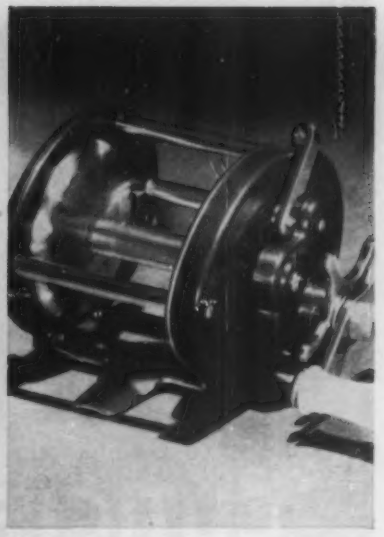
**For the recreation market** plastics help many products escape the limitations of older materials. A trio of Dow thermoplastics lend their specific talents to a fishing tackle box, a fishing reel, and an underwater mask and swim fin outfit . . .

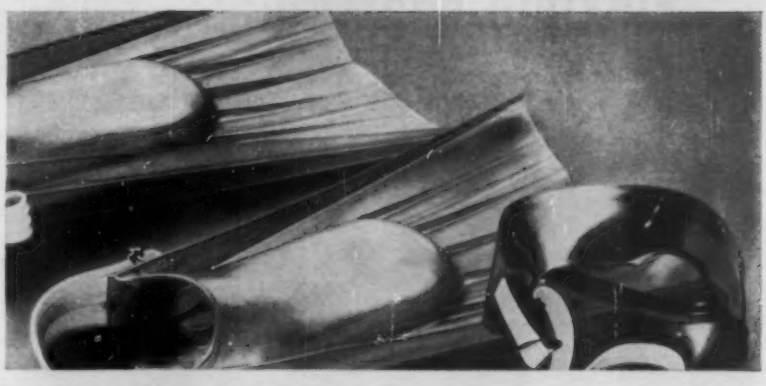
**Built to last for a lifetime** of fishing, the tackle box is molded of economical Styron® 480, a Dow super-high-impact plastic formulation with a green and white marbleized color effect. In addition to the inherent toughness to withstand a fisherman's hard knocks, Styron 480 has high heat resistance to endure the blazing hot sun without softening or warping. The excellent molding properties of Styron 480 – with emphasis on flow characteristics – allow the molder to produce a unique tongue and groove design along the edge. This makes the box watertight when closed—even allows it to float!

**A colorful, economical solution** to a design problem, this casting reel's end caps and knobs are molded of tough Styron 475. Styron 475 is a high impact formulation of the Dow family of polystyrene materials. Its impact strength is three to five times greater, and its elongation nine times greater, than general purpose polystyrene formulations. It resists salt water deterioration, and has good chemical resistance. Its fine molding characteristics reproduce sharp details faithfully.

**Molded of an easy-to-process resin,** an underwater face mask and swim fins of Dow PVC will last far longer than conventional materials. PVC permits the mask to fit snugly and comfortably across the face of the swimmer, with a sealing lip around the edges to prevent water seepage.

The PVC swim fins are lighter and stronger than conventional fins. What's more, the sun will not fade or rot PVC. Dow PVC is available in several different formulations. This wide selection permits a range of PVC compounds to fit almost any process or end use.

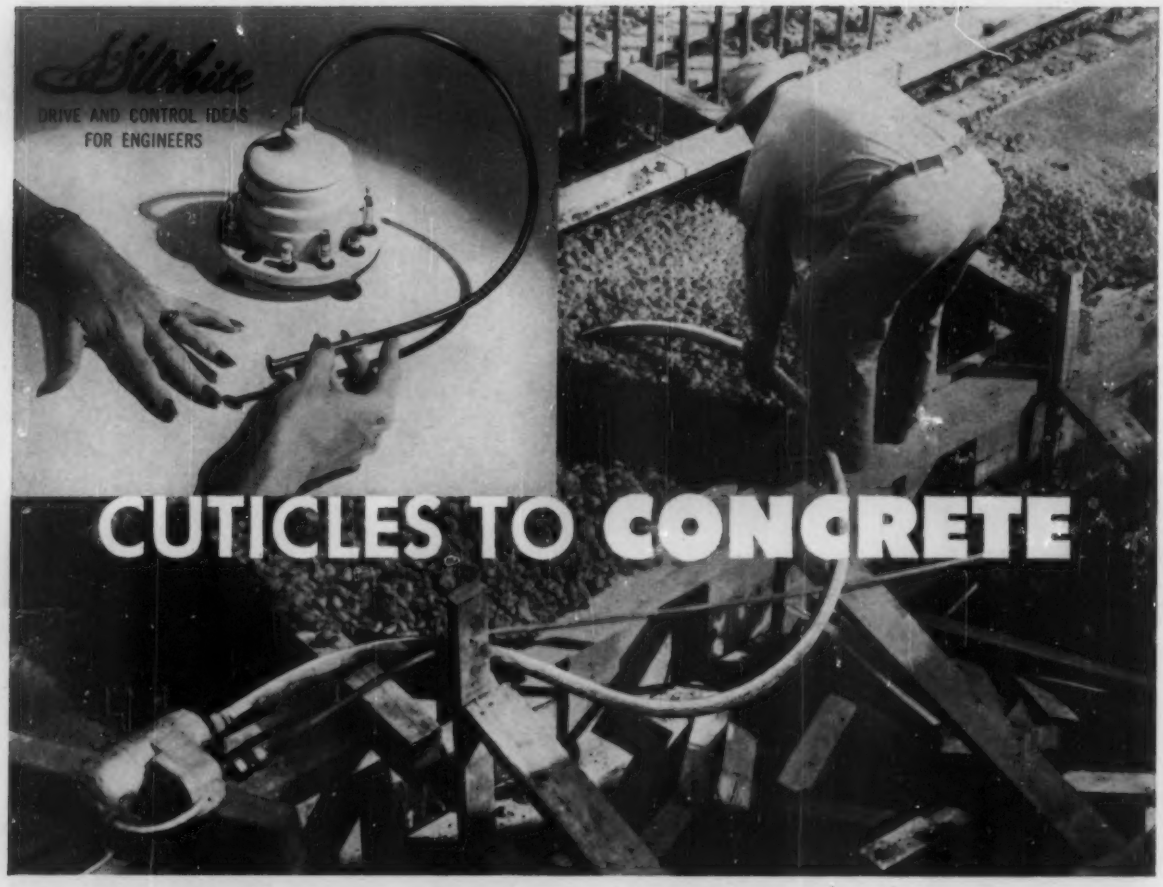




**PROBLEMS, ANYONE?** If a design or processing problem is puzzling you, chances are there's a formulation within the Dow Family of Thermoplastics that will solve it. If we can be of any assistance in helping you select the right formulation, or in production techniques, color styling, etc., please write us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1720DZ7-11.

**THE DOW CHEMICAL COMPANY**
Midland, Michigan

DOW




# Flexible shafts carry torque to spare...

Whether your product requires delicacy or raw strength, there's a flexible shaft available from S. S. White to transmit rotary power or control.

For example, the .043" dia. flexible shaft in the manicurist's tool transmits approximately 0.38 pound-inches at high speed and provides extreme flexibility of operation – suitable to M'Lady's finger-tips. Or, consider the Viber Concrete vibrator which needs a .437" dia. shaft, capable of transmitting high torque at 10,000 rpm under brutal field conditions.

Keep flexible shafts in mind for applications other than power tools, too. They allow the designer important – sometimes vital – latitude in positioning both power source and driven part... freedom to snake power around obstacles, freedom to obtain balance and structural economy.

Flexible shafts solve a lot of other problems too. They help you to elimmate parts . . . expensive, cumbersome gears, drives, universals. Make installation easier because they have no alignment problems. Machine performs better too, because vibration, shock, overloads are absorbed by rugged flexible shafts.

Whatever your problems, look into S. S. White's three lines of flexible shafts: Standard ...Pre-Engineered...Custom-Designed. There's bound to be an answer for you.

**S. S. White Industrial Division, Dept. 14**
**10 East 40th Street, New York 16, N. Y.**

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Standard S. S. White flexible shafts are available "off the shelf," making many savings possible. **Write for bulletin 5801.**

S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements. **Write for bulletin 5601.**

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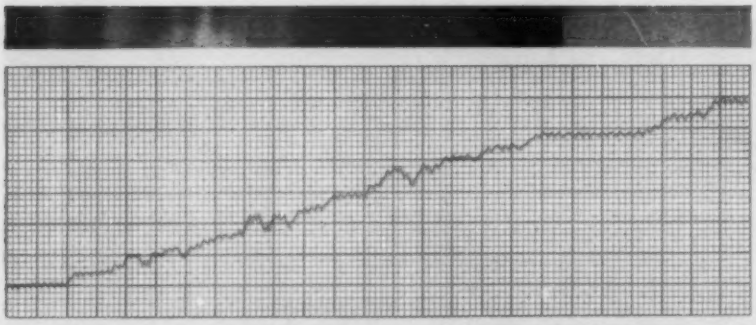
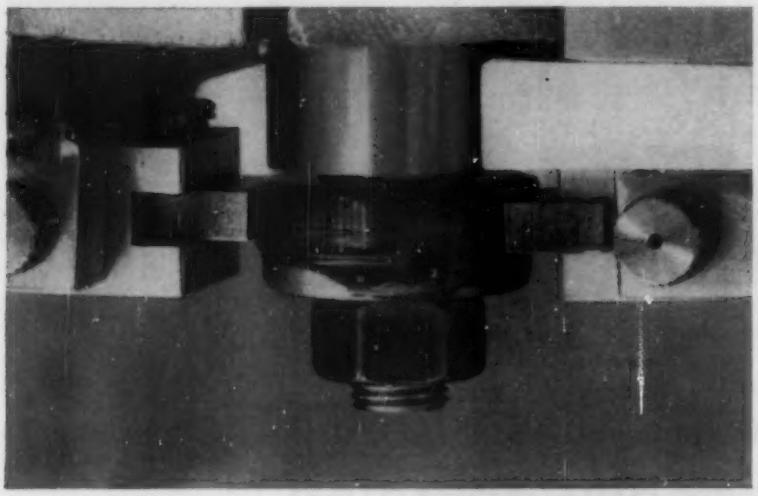
S.S.White
FIRST NAME IN FLEXIBLE SHAFTS

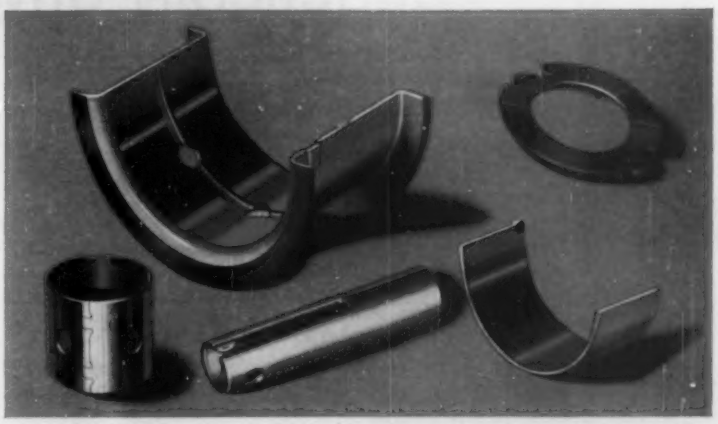
# WE TAKE THE PULSE OF BEARINGS ON TAPE TO MAKE THEM EVEN BETTER!





**TO TAPE-RECORD THE "HEARTBEAT" OF BEARING METALS UNDER LOAD, WE USE THIS SPECIAL FRICTION AND WEAR TESTER.** (left) The result is highly accurate data on the behavior of bearing-metal surfaces, invaluable in our fundamental research into friction. By means of this instrument, we're able to correlate, more closely than ever before, specific alloy compositions with their degree of the "stick-slip" phenomenon (in which one surface sliding over another slides . . . stops . . . slides . . . stops . . . and so on) which accompanies unlubricated sliding action. We can also determine accurately the compatibility of bearing materials with shaft metals in lubricated systems . . . showing us which metal or alloy is most likely to be superior for a given bearing application. In short, this Friction Tester is a fundamental research tool which gives us positive answers to difficult bearing problems, faster than ever before.

**ONE REASON WHY F-M SLEEVE BEARINGS** and other F-M products give you the finest possible performance — this and the other unusual precision equipment used by Federal-Mogul research. You'll find F-M sleeve bearings used in turbines, engines, and countless other types of power transmission equipment . . . F-M precision thrust washers in pumps, automotive engines and transmissions, motors . . . F-M formed bushings in refrigeration compressors, electric motors . . . and low-cost F-M spacers in motor mounts, machinery, control mechanisms. These are just a few examples.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers, and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

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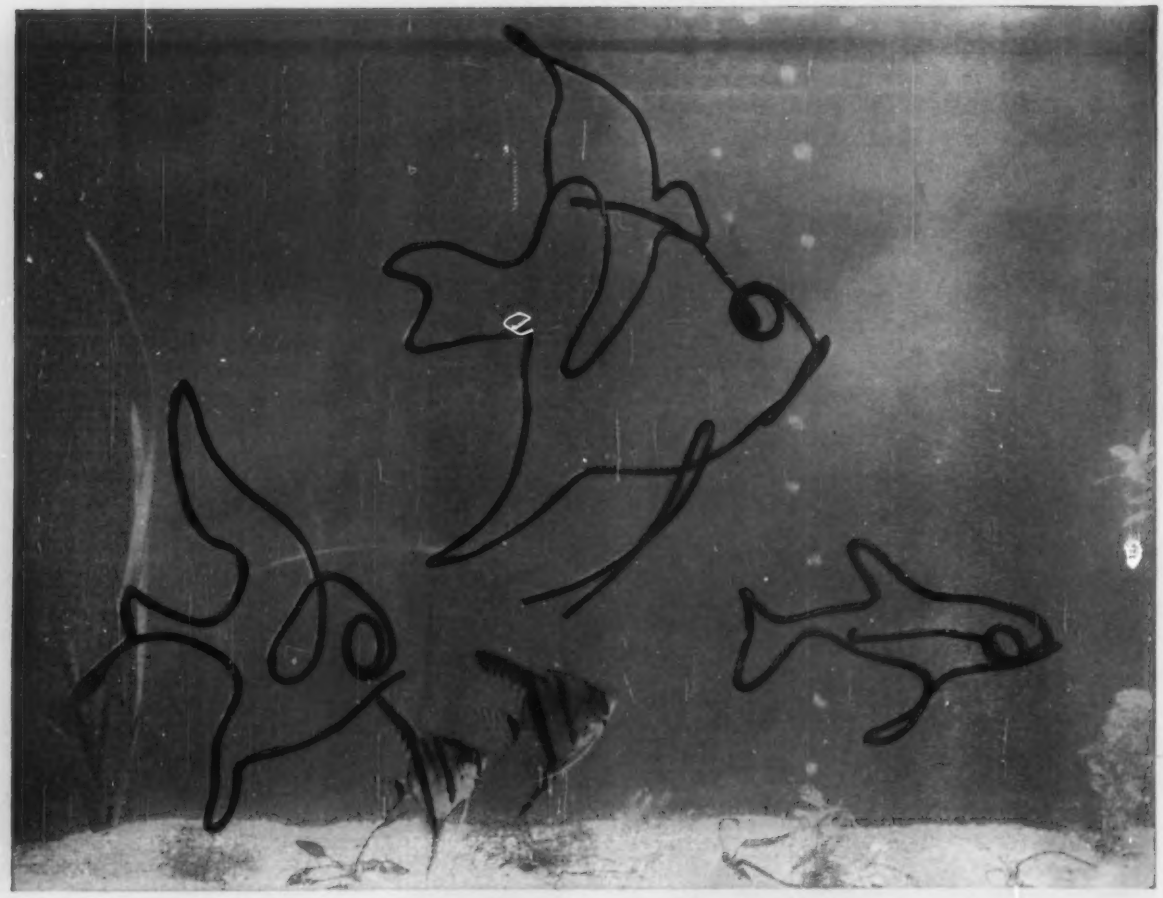


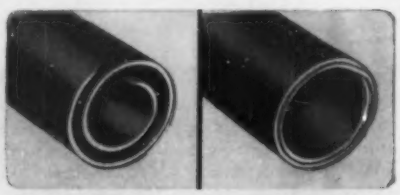
# Bundy can mass-fabricate practically anything

## . . . and we use Bundyweld®—the double-walled steel tubing—for parts that must meet rigid specifications

YOUR tubing headaches are Bundy's business. Our tubing engineers will work with you at any stage in the development of your product. With years of problem solving experience, we can often suggest short cuts that cut costs of tubing parts—or find practical solutions to tough bends.

Then we'll mass-fabricate these parts on machines specially designed by Bundy for precision bending. We use Bundyweld, the original double-walled steel tubing, that has become the safety standard in small-diameter tubing. It's thinner walled—yet stronger, has high bursting and fatigue strengths. Covered by Government Spec. MIL-T-3520, Type III.

Why don't *you* take advantage of Bundy's complete service: expert engineering help, mass-fabrication savings, *Bundyweld* tubing. For more information see Sweet's Product Design File, le/Bu . . . or contact us!



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ½" O.D.

*There's no substitute for the original Bundyweld Tubing.*

# BUNDY® TUBING COMPANY

HOMETOWN, PA. • DETROIT 14, MICH. • WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

# To OEM's who want to reduce the size of their control panels

The small size of General Electric panel components offers OEM's the opportunity to reduce the size of their panels up to 40%. Consider these two examples:

**Example 1:** Suppose you lay out a panel—including several size 1 or 2 starters or contactors—and the devices you choose fill up 900 square inches of space. To meet JIC standards, you must then enlarge your panel to 1170 square inches (adding 30% of clear panel mounting space). Because General Electric starters and contactors in these sizes are from 10 to 50% smaller than those of other major control suppliers, you can avoid enlarging your panel beyond 900 square inches by using G-E devices. And you can still meet the standards and save on the sheet metal and labor required for a larger panel.

**Example 2:** If you build motor control centers in 7-, 9¼-, and 14-inch modules, you can stack General Electric size 2 starters eight compartments high. (This compares to five for most leading control manufacturers.) Thus you can save in steel work and up to 40% in the user's floor space.

Similar advantages of small size, minimum wiring time, mounting convenience, and fast delivery are available with not only starters and contactors but also with General Electric relays, pneumatic timers, and push buttons. You can get *some* of these advantages from other manufacturers of panel components, but General Electric offers *all* these measurable advantages — and the greatest over-all savings to you.

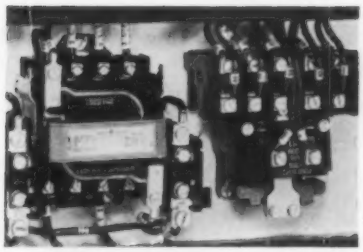
For more information, contact your General Electric Apparatus Sales Office or request bulletins GEA-7020 (magnetic starters), GEA-7021 (relays), and GEA-5779 (oil-tight push buttons) from General Electric Company, Section 811-09, Schenectady 5, N. Y.

You get **MEASURABLE ADVANTAGES WITH GENERAL ELECTRIC CONTROL**

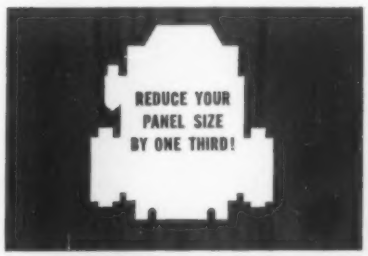
*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

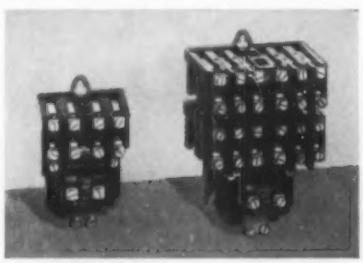
CIRCLE 53 ON READER SERVICE CARD



**SIZES 0 AND 1 STARTERS** are 42% smaller than previous forms and about the same height as G-E 4- and 6-pole machine tool relays. Straight-through wiring means no looping of wiring around sides; only ½-inch side spacing required between starters.




**SIZE 2 STARTERS** are 34% smaller than previous forms; can reduce your panel space by 1/3. Wiring, coil, contacts, and overload relays are all accessible and removable from the front, eliminating need for extra space around the device.



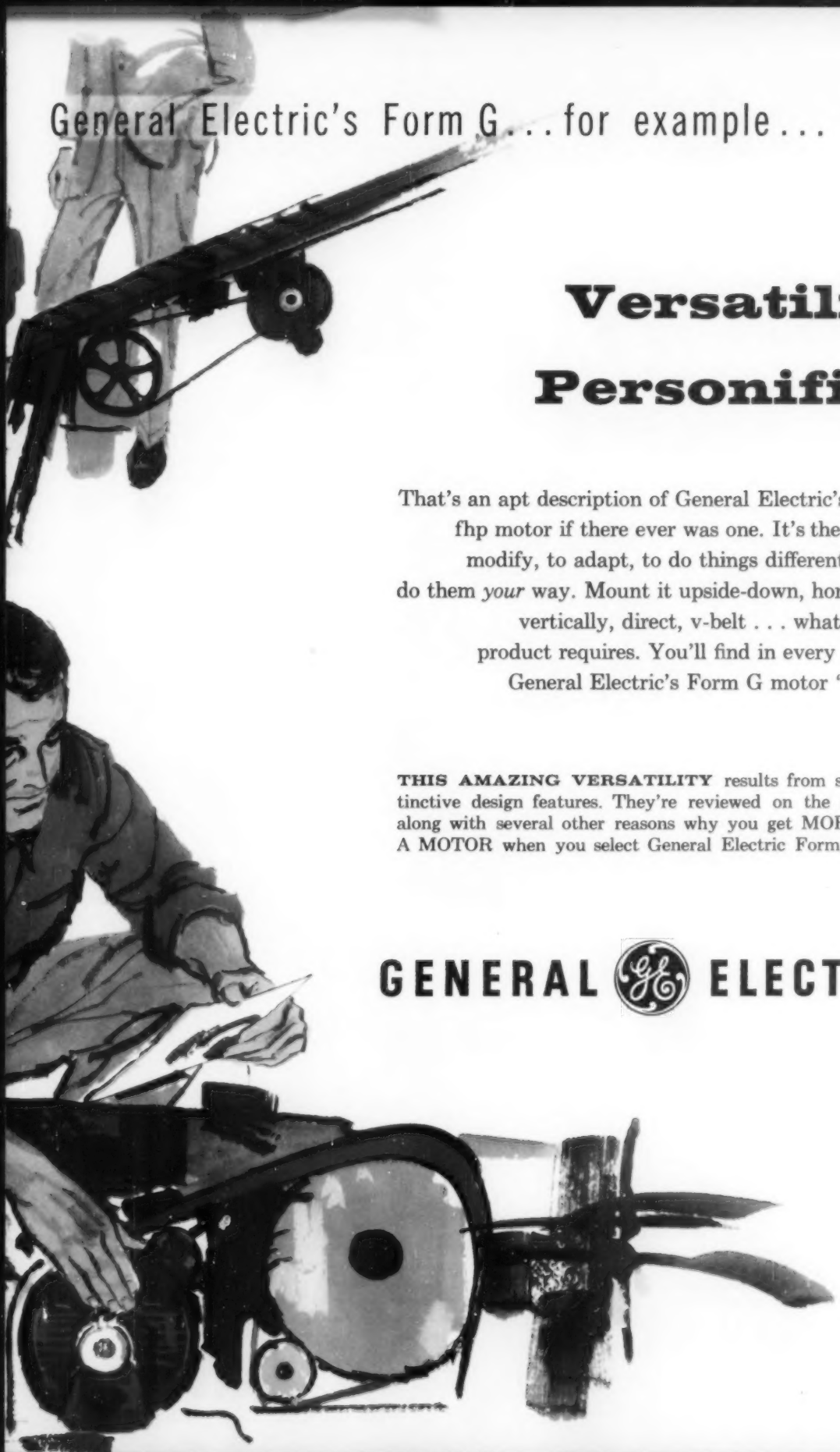
**COMPACT RELAYS** save space, simplify installation and inspection. Less wiring room is needed because all terminals are in front. Machine tool relays are available in 2- through 12-pole forms.

**2-IN-1 ILLUMINATED PUSH BUTTON** replaces standard oil-tight button and light. This means a saving in money and a measurable 50% saving in space.

CIRCLE 54 ON READER SERVICE CARD→

You get MORE THAN A MOTOR with

General Electric's Form G . . . for example . . .



# Versatility Personified

That's an apt description of General Electric's Form G fhp motor if there ever was one. It's the ability to modify, to adapt, to do things differently . . . to do them *your* way. Mount it upside-down, horizontally, vertically, direct, v-belt . . . whatever your product requires. You'll find in every case that General Electric's Form G motor "can do".

**THIS AMAZING VERSATILITY** results from several distinctive design features. They're reviewed on the next page, along with several other reasons why you get MORE THAN A MOTOR when you select General Electric Form G motors.

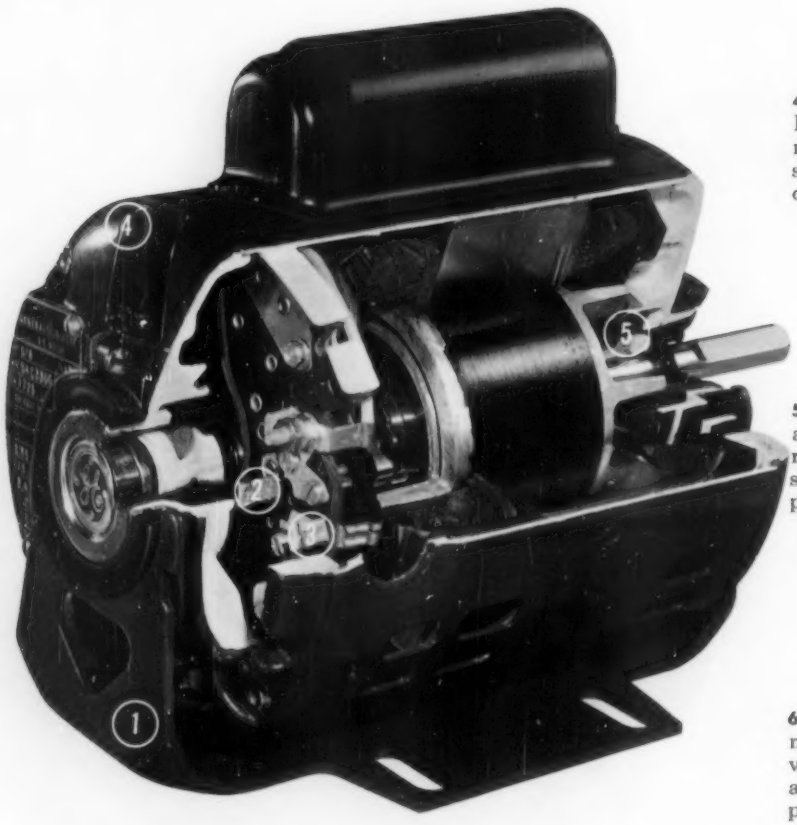
GENERAL ELECTRIC

# These Form G motor versatility features mean greater design freedom for you

**1. MOUNTING VERSATILITY**—Both resilient and solid cradle bases permit rotation of General Electric Form G motors within base to meet your product design and space requirements.

**2. FAST ROTATION CHANGE**—No need to specially order motors to meet your rotation requirements. Just interchange two motor leads; reverse shaft rotation in seconds.

**3. FAST VOLTAGE CHANGE**—Sliding plates on terminal boards allow change from 115 to 230 v operation (or vice versa) in one-fifth the time without confusion or error.




**4. EASY, DIRECT MOUNTING**—Mount Form Gs directly without expensive machining or brackets. Close end shield tolerances allow mounting of motor with simple through-bolts.

**5. ALL-ANGLE OPERATION**—All-angle sleeve bearing and positive oil retention system allow you to mount standard Form G motors in any position. No need for costly specials.

**6. COMPLETE LINE**—Over 850 basic models—and literally thousands of variations—mean there's a standard Form G motor to meet your product's *exact* requirements.

## Only General Electric Form Gs give you MORE THAN A MOTOR

**1. VERSATILITY PERSONIFIED**—a Form G motor can meet almost any design requirement.

**2. EXPERT APPLICATION AID**—G-E engineers are always available to help solve unusual motor applications.

**3. ON-TIME DELIVERY**—multi-plant facilities assure you reliable, prompt delivery of the exact motors you need.

**4. YEARS-AHEAD DESIGN LEADERSHIP**—consistent leadership by G.E. keeps Form G motor customers "out front".

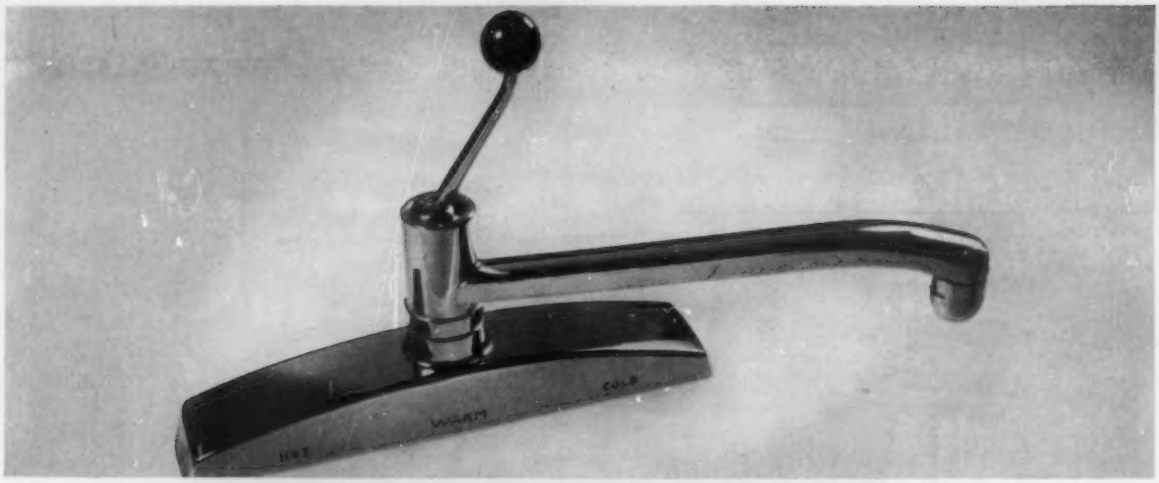
**5. EASE OF ASSEMBLY**—Form G motors provide assem-

**6. FAST, LOCAL SERVICE**—a nationwide network of G-E Electric Motor Service Stations means service is always close at hand.

**7. QUALITY CONTROL**—*every* Form G motor is thoroughly tested at all stages of production to assure you long, dependable performance.

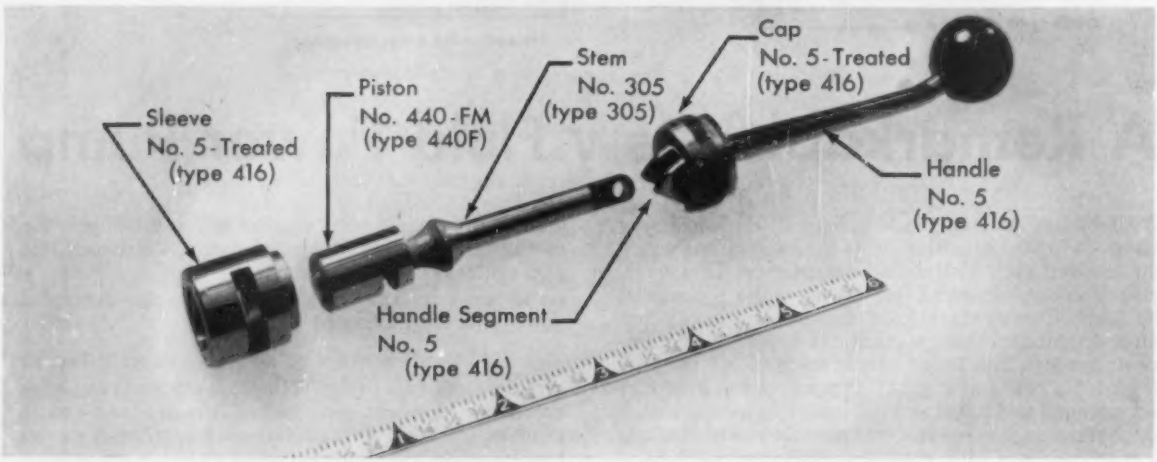
**Make sure you get MORE THAN A MOTOR when you select fhp drives for your product . . . choose General Electric Form G motors, available in NEMA 48 and 56 frames. For more information contact your nearby General Electric Apparatus Sales Office or write Section 702-110, General Electric Co., Schenectady 5, N. Y.**

GENERAL ELECTRIC




for strength, corrosion resistance and sales appeal

## ...it had to be Stainless

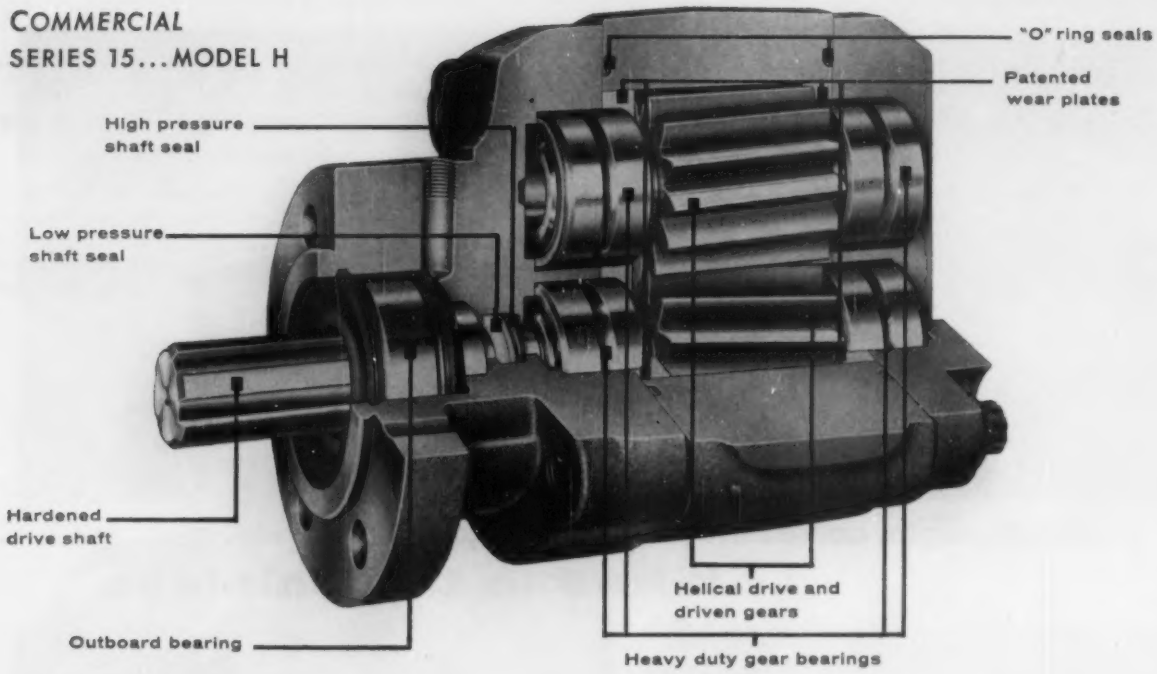



*In this new one-handle mixing faucet all the important working parts are made of wear-resistant, corrosion-proof Carpenter stainless steels. Once you select stainless steel by Carpenter, you can forget about corrosion. You can design for high stresses, disregard maintenance problems, stop worrying about temperature variations and be assured that fabrication will be easy. And you not only get the help of consumer-acceptance of stainless products, but also the long experience of Carpenter. From the lab work through final production, Carpenter staffmen have the knowledge and the data. Call your Carpenter representative for the engineering information on stainless that you need. The Carpenter Steel Company, Reading, Pa.*

**Carpenter steel**

Steel

*The Carpenter Steel Company, Main Office and Mills, Reading, Pa.*
*Alloy Tube Division, Union, N. J.*
*Carpenter Steel of New England, Inc., Bridgeport, Conn.*
*Webb Wire Division, New Brunswick, N. J.*




# A Remarkable New Fluid Power Pump

COMMERCIAL presents the new, Series 15H fluid power pump—a logical extension of its Series 36H line which has received such outstanding acceptance. This small powerhouse possesses all the proven basic features of the larger COMMERCIAL fixed displacement gear pump but is designed for those applications where flow requirements are less. The Series 15H is made in ½", ¾", 1", 1¼", 1½", 1¾" and 2" gear widths and covers a delivery range from 3 to 15 gpm at 1200 rpm. It is recommended for continuous duty operation at pressures up to 2000 psi — at speeds up to 2400 rpm. Volumetric and mechanical efficiency rate over 90%. 15H pumps are available for flange or pad mountings of many styles and can be furnished with ports to accept tapered thread, straight thread or SAE split flange fittings.

**High performance for keeps**

Perfect alignment is "built in" these pumps because of their unique basic construction which establishes the machining of all parts from one common reference, the gear center line. (See drawing.)

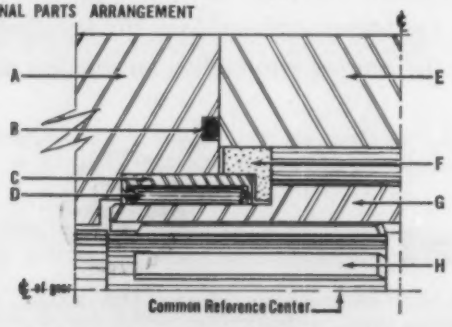
As shown, gear bearings also act as dowels—outmoded dowel pins are eliminated.

Matched helical gears having mirror finish ground on all surfaces contribute to high volumetric efficiency and quiet operation. Thus, complete sealing is maintained—tooth to tooth and tooth to gear housing. Ruggedness, greater load capacity and dampening of unbalanced internal loading are assured by using integral gear-hubs to serve as journals for the pump's oversize gear bearings. In order to meet its own exacting standards, COMMERCIAL must, and does, produce its own gears.

A dynamic seal is maintained between gear faces and special bronze alloy gear thrust plates. The entire thrust plate "closes in" against the gear face because of pressure pocketed behind the plate, thus compensating for any wear on its gear contact surface. Because the sealing area is confined to a small portion of the contact surface, the amount of friction has no appreciable effect on pump mechanical efficiency.

Engineering experience available—personal technical service and assistance is yours for the asking. For more information write to Commercial Shearing & Stamping Company, Dept. G-29, Youngstown 1, Ohio.

INTERNAL PARTS ARRANGEMENT




A-bearing carrier B-"O" ring seal C-bearing outer race D-bearing roller
E-gear housing F-floating thrust plate G-gear H-drive shaft spline

*pumps, valves, cylinders, motors*

**COMMERCIAL** *shearing & stamping*

PRODUCT ENGINEERING HORIZONS

JULY 11, 1960

# WHEN THE ENGINEER SAYS "FORE!"

There's an old story about a golfer who turned to his caddy in a difficult spot near the green and said, "Which club shall I use?" The caddy looked over the pitch and offered a 9 iron. "I'll take the putter," said the golfer. The caddy shook his head but handed out the club. With it, the golfer swung, connected—and holed out. "Now what club do you think I should have used?" he asked. The caddy looked him over and said, "You still should have used the 9 iron."

In other words, in golf as in most other things, you can sometimes do the right thing the wrong way. In these days of caddy carts and electric buggies, the only advice a golfer gets is from his associates—which is usually the equivalent of the Biblical blind leading the blind. The modern golfer has a much better chance to perfect his errors through practice, playing game after game on one or two local courses.

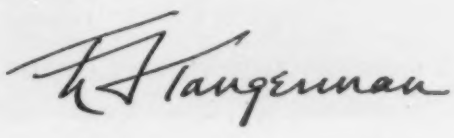
In golf, the rate of change is very low. No golfer will admit it, insisting there are endless variations, but meanwhile removing vagrant leaves and twigs and playing winter rules to better a difficult lie. Not so in design engineering—or at least in most design engineering. Some designers there are who merely add a new annual curlicue to the whipsocket pattern, but most are faced with constant change. They have to play the ball where it lies, whether behind a tree or in a ditch.

Because the rate of change is so great, the books and instructors and rules are likely to be out of date too. The tools may be inadequate or obsolete, and there isn't too great a selection. It's vital to keep an eye on the ball, too, because playing a second, even if you lose the first, is not allowed. And a second try to improve a lie has quite a different meaning in engineering than it does in golf (or in politics, for that matter).

There are plenty of "caddies" willing to give advice, but unwilling to hold the bag either during or after the play. And besides, their advice isn't worth a great deal, because you're likely to be playing a new hole, one no one has seen before and with traps in places that experience can't predict.

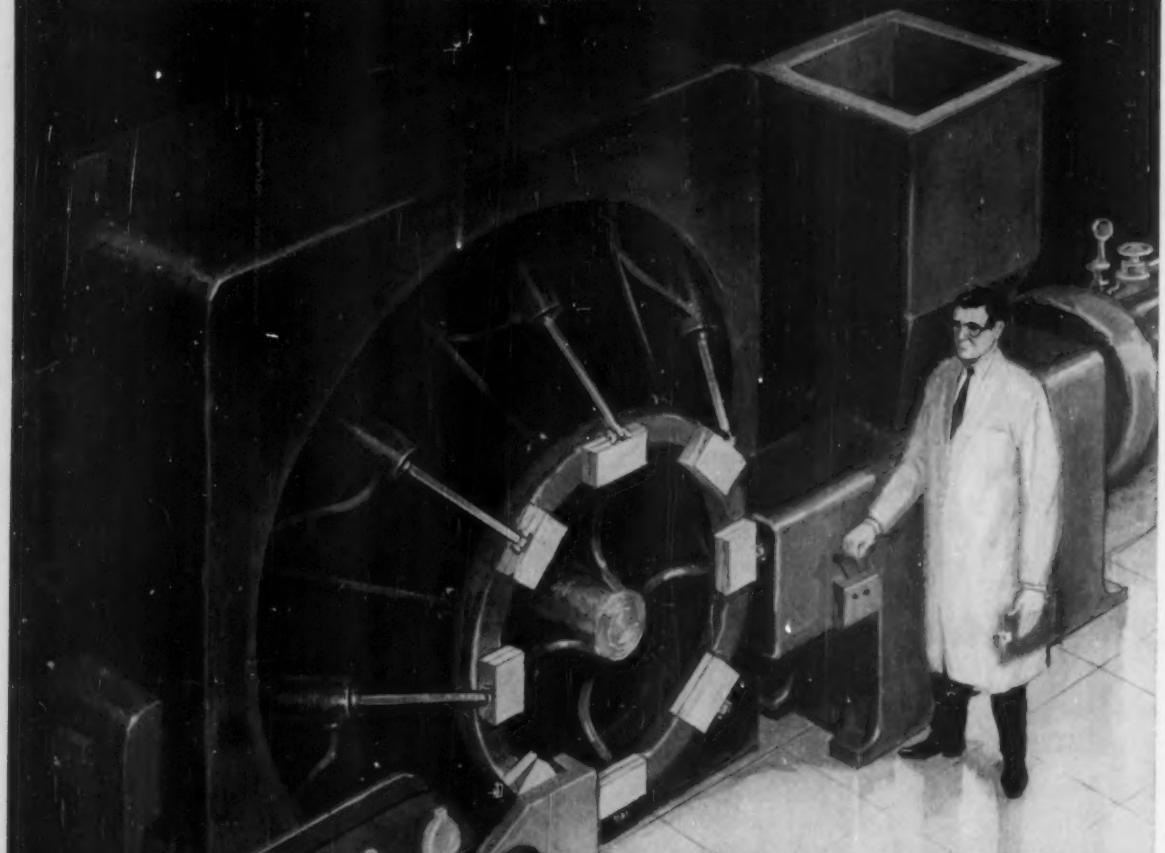
All the designer can do is to look over the lie and then see what he has in clubs. He'll almost certainly have to convert one, may have to make a new one to suit the job. From then on, it's head down, firm grip, good pivot, clean swing and follow-through—particularly the latter.

Nerve and luck may put him on the green and in the money. It's a cinch that a bagful of old clubs and old books won't do it.



SIGNIFICANT ADVANCES IN BERYLLIUM TECHNOLOGY COME FIRST FROM BRUSH

# BERYLLIUM COPPER HELPS BLOW MOLDERS FILL HUGE DEMAND



**Cast beryllium copper molds allow shorter molding cycles, give longer, more economical production runs.**

Blow molders produced 500,000,000 polyethylene containers last year. This year, the big question seems to be, "Can they puff out enough containers to meet the expected one billion demand?" Molds made of beryllium copper offer part of the answer.

For mold makers, this Brush-supplied alloy is easy to cast to shape without expensive machining, simple to heat treat to hardnesses of Rockwell C44 and tensile strengths to 175,000 psi. For producers of plastics, tough beryllium copper molds last longer, reducing replacement downtime. The alloy's high thermal conductivity aids in shortening mold cycles for more output per machine hour.

Molds for plastics may not be your problem, but Brush may have the answer to some of your tough material requirements. For more information on beryllium, its oxide and its versatile alloys, contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.

THE BRUSH BERYLLIUM COMPANY

# DO YOUR OWN VALUE ENGINEERING

**Squeezing the manufacturing cost out of a product has become the value-engineer's job. But if your company doesn't yet see need for such specialists, you can still apply some of the principles of this new discipline yourself.**

**RILEY A MURRAY,** *production design specialist*
*Goodyear Aircraft*

Cost analysis begins at home—at the design engineer's desk. He has the initial responsibility for the design, it is his job to ensure that the product performs the intended function at the least expense.

But this is a big job—more than most engineers are capable of handling, and more than they have been trained for. That is why many companies have added the two-phase function of value engineering to the cost analysis hierarchy. In the first phase (value assurance) a trained value engineer works with the designer to advise him of the cost of alternative designs. In the second phase (value improvement), a committee of engineers experienced in various phases of product manufacturing perform a post mortem on the completed product to recommend money-saving modifications.

Some companies do not yet believe the two levels of cost-shaving are necessary. In these organizations, the design engineer bears the full burden for whatever value engineering is done. This can never be a substitute for a company-sponsored program. But if individual designers familiarize themselves with some of the principles of value engineering, they will be able to trim manufacturing costs significantly and, at the same time, demonstrate to management the possibilities of a full-fledged value-engineering program.

### Complexity is the problem

Why have many companies set up two extra operational levels to do a job that the design engineer is usually expected to perform on the first run-through? Simply because the technological world is too complex, the alternative schemes too obscure, the variety of materials too broad, and the economic choices too specialized for one design engineer. The fact that another person or group can make improvements does not mean that the engineer wasn't doing his job. Value engineering requires special training.

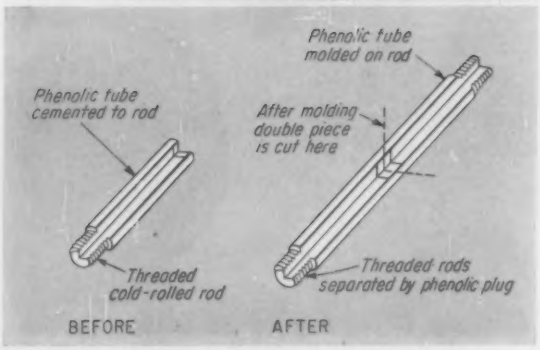
Properly handled, it quickly pays dividends. One, two, even three or more redesigns are practical as long as the product is substantially improved at each stage. There are very few products that cannot be successfully value-engineered to reduce cost or improve performance.

Consider the cost of the raw materials in today's designs. Everyone knows that electronic equipment is expensive, but few realize just how expensive. On the basis of bulk, transistors cost about $300 an ounce. Compare this with $35 an ounce for gold. Diodes are approximately $180 an ounce; precision resistors and tantalum capacitors both cost in excess of $75 an ounce. Mechanical parts are expensive too. Miniature switches run about $50 an ounce while miniature bearings can average as high as $95 an ounce.

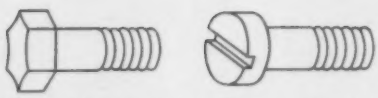
This is just a fraction of the cost of the completed equipment. In a missile guidance system, only a small part of the cost is tied up in components; over half is in the packaging and in the electronic (or mechanical) elements linking the components. If the cost of these "solid gold" designs can be reduced just 5%, the returns on the value engineering invested can be large indeed.

Whether this reevaluation is done during design by a trained value engineer or during manufacture by a group of value engineers, the goal is the same: To achieve the essential function at lowest possible cost, and still maintain reliability. On the surface it would seem logical to

## Value engineering does this


Phenolic tube molded on rod
Phenolic tube cemented to rod
After molding double piece is cut here
Threaded cold-rolled rod
Threaded rods separated by phenolic plug
BEFORE
AFTER

**BRUSH-HOLDER STUD** for a large electric motor was originally made by cementing a phenolic tube to a threaded steel rod. Cost: $1.74 apiece. The value-improvement group, with suggestions from the vendor, recommended that the part be made by molding the phenolic around two threaded rods separated by a ¾-in plug. These double-ended parts could then be cut apart to give two studs costing $0.70 each. Saving to the company: $3000 a year. Value improvement was effected by General Electric's Value Analysis group with suggestions from National Vulcanized Fibre Co.



**A COMPARATIVE ANALYSIS** in this simple example quickly shows which fastener is least expensive to make. In both cases the stock must be cut to length, turned to the shank diameter and threaded. But the cap screw begins with hex stock, needs no further operations to make a finished fastener; the round stock of the machine screw must be slotted. This additional operation represents an unnecessary expense in most applications.

make changes before manufacture, rather than after. Actually, experience has shown both steps are important. There is no need to choose between them; they complement each other and together can achieve substantial savings.

### Assurance vs improvement

The essential principles of value engineering have been applied for many years under titles such as Cost Analysis, Producibility, Cost Engineering and Engineering Cost Control. Value assurance before manufacture, for example, has been practiced by Lockheed, Northrop, and Martin for over 10 years. It is an engineering-department function, usually performed by one man. In general, the most efficient value engineering is produced by the smallest group capable of doing the job.

A good value engineer has considerable design experience and is fully acquainted with the plant facilities and manufacturing methods of the company. With his general knowledge he can cure most of the designer's troubles. If an evaluation is complicated or specialized, he refers it back to his department for detailed study. Because problems are caught during development, the delay for the detailed study is usually more than offset by the simplifications in the improved design.

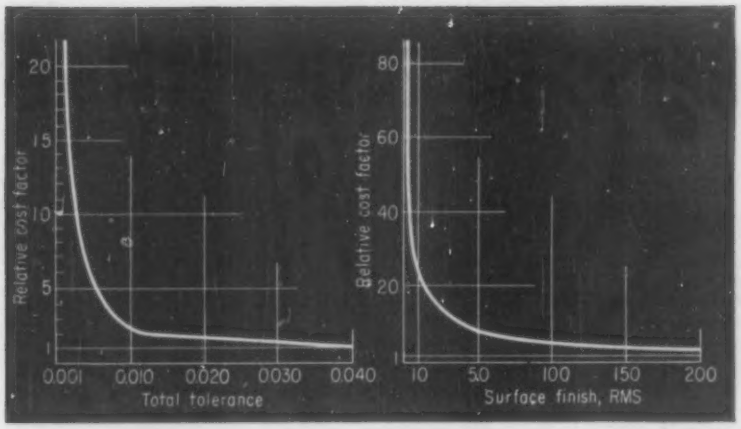
Value improvement aims at increasing product value when there is a finished item available and actual cost records can be reviewed. This is primarily the technique of the much-publicized Value Analysis group originated 13 years ago by L. D. Miles of General Electric. Main objections to the value-improvement technique are that many industry executives believe costs should be cut before the design leaves the engineering department and that after-the-fact appraisals hold up designs at a critical stage of their development.

Certainly much greater savings can be made if changes are made before the design gets to production. But large savings can be (and have been) made with value-improvement teams, composed of such experts as value analyst, operations planner, cost estimators, etc. GE teams have improved enough products to show that such second-guessing can be profitable.

### There are a few dissenters

But some argue the worth of any kind of value engineering. They say it is only common sense in that the designer should be responsible for conceiving the lowest cost product for a given function and cost analysis need go no further. But the same objection could be made to establishing a special group for stress analysis or for checking drawings—and with more logic since these are things an engineer is supposed to know. Few engineers, however, have had training in value engineering. And most companies find it more effective to have a staff of highly trained value engineers who are not hindered by other engineering considerations, just as stress problems are best handled by stress engineers.

The oldest argument against a value-engineering group, and the most difficult to overcome is the opinion that "It won't work in our case." Only actual experience can change this reluctance to accept new ideas—and the experience can be obtained at little or no cost. Have your product value-engineered. Even if savings are only half what could be realized with a thorough analysis by your own staff, they will undoubtedly offset the cost of the




**RELATIVE COST** of tolerances and finishes is not a straight-line relationship. With a looser tolerance or a rougher finish, manufacturing cost can be reduced significantly.

analysis. Suppose you make 10,000 items costing $10 apiece. A value-engineered saving of only 10% will amount to $10,000—a worthwhile improvement even if it costs $5,000 to get the job done. The few instances when a product can't be value-engineered to show a saving are readily apparent to a trained value engineer.

Despite these arguments, many companies have no value-assurance men or value-improvement groups; getting the most product for the least money is a matter that begins and ends with the engineer himself. Can he be trained to do his own value engineering and to be made more aware of the considerations of cost and reliability? To a limited extent, yes.

### The do-it-yourself approach

Value engineering can be performed by anyone who has the authority to specify, in part or total, a product or method of operation. Most engineers are a part of working management and have the responsibility to incorporate as much value as possible into those items under their control. This is just as true for the draftsman of clips and brackets as for the senior engineer with responsibility for design of major components.

To put value into your product you need only a tool you already own but seldom recognize because you use it unconsciously. This tool is a comparative analysis—the same one, with additional refinements, used by the professional value engineer.

He divides comparative analysis into two segments: observational analysis—a comparison of different forms, different tolerances, different materials that perform the same function; and operations analysis—a comparison of various methods of fabrication. He breaks both down into great detail with an item-by-item list showing differences between competing proposals. He puts these in terms of dollars, because he must resolve opinions of various groups and the dollar is the only common denominator understood by all.

In your analysis you do not need the professional value engineer's fine detail. Rough comparisons are satisfactory and will usually prove the superiority of one method over another. In observational analysis, for example, you will quickly see that if the design will allow larger tolerances or rougher finishes, the savings will be large and the value increased accordingly.

In a comparative operational analysis, on the other hand, a short list of the manufacturing steps for each of the alternative methods will reveal which of the two is the more expensive. Eliminating unnecessary operations, standardizing similar parts, specifying less expensive materials . . . these can all be evaluated quickly on the basis of comparison.

Although your efforts as an individual will be minor when compared with a company-sponsored value-engineering program, the results can be amazing. You will have the satisfaction of doing a better job and will receive recognition as you increase your worth to the company. You can cure many of your headaches by prescribing your own value-engineering "aspirin."

In reply to the professional value engineer's indignant screams that this do-it-yourself approach is not true value engineering, I apologize. In justification I say that we must learn to crawl before we can walk. And some of the crawlers will eventually walk into top management where they will help to sell a company-sponsored value-engineering program.

**EDITOR'S NOTE:** These previous articles examine comparative manufacturing costs in more detail and discuss further aspects of value engineering and its older brother, cost control.

**Designing with Dollars,** Mar '48 p 81—Pointers for analyzing cost of a design, with a list of cost-savers.

**Designing for Lower Costs,** June '49, p 81—88 page special report with curves showing comparative costs of materials and case histories of a variety of products redesigned for lower cost.

**Design Cost Control,** Sept '49, p 81—Cost-control engineers team up with designer to evaluate design alternatives. An example shows analysis of four ways to make a fitting, and cost for each.

**Producibility Check List,** Dec '55, p 174—A summary of those factors you need to consider when improving a design to give less weight, lower cost, less complexity.

**Engineering Economics,** Feb. '55, 6 187—How to set the engineering budget and meet it through cost records.

**Value Control—Extension of Value Analysis,** May '57, p 155—The two levels of value engineering—first in the design room and later in production and purchasing—as developed and executed at General Electric.

# HARD HARNESS for EASIER WIRING

*The covering of molded resin and fiberglass keeps wires from running wild and provides a rigid bundle that effectively takes abuse.*

**NORMAN R LAY,** *lead designer, Production Design, Aeronautics Div, Chance Vought*

1

2

3

**1 Wire bundle is prepared** on harness board by usual methods; corrugated fiberglass tubing protects wires for runs outside the portion to be molded . . .

**2 . . . the mold is prepared** by inserting a lining of resin-impregnated glass cloth. Wire bundle is then placed inside the lining, the covering is folded . . .

**3 . . . over the bundle,** and the mold closed under pressure. After curing and cooling, the mold is opened and the cable assembly removed . . .

**4 . . . installation shows** advantages of hard harness—its casing provides both structural support to the bundle and protection against damage during installation and in service.

What can you do with the maze of wires the "black box" designers say are necessary for their equipment? Invariably, the first estimate of size of a wire bundle always seems about ½ in. dia, but somehow it swells to 2 in. or more by final installation. Everyone assumes the bundle can be tied, divided, changed, bent, twisted, and routed in any direction. But when the time of reckoning comes, these easily bent wires suddenly become pretzel-shaped pythons that try to strangle you.

Wiring systems must last the life of the product and this requires protection both in installation and against service abuse. Chance Vought's molded cable system provides this protection with a covering of molded resin-impregnated fiberglass. Encasing the wires replaces metal conduits, string ties, and wrapping the wire bundles with abrasion-resistant tapes. It also reduces the number of clamps and supports, and retains the wire bundles in place.

Molded cable assemblies will withstand an operating temperature of 300 F, yet cost little more to fabricate than a conventional cable assembly for bundles of 40 wires or more. The method provides for a full range of wire types, and offers custom-made molded cable assemblies when needed. It saves weight as compared with standard airframe wiring.

Wire in the molded cable assemblies is given a water-bath dielectric test per specification MIL-W-16878, and packaged one length to the reel with a protective layer of polyester firm sponge wrapped around the reel of wire. All sharp edges are carefully removed from the work areas.

Wires are taped into bundles on harness boards, and then molded in forms. Next, the assemblies are tested for insulation resistance and continuity. Spare wires are provided for circuit changes and future growth of the electrical system. Field repairs are made by completely replacing the molded cable assembly or routing wires adjacent to the molded cable until a spare assembly is available.

Molded cable is most effective in areas needing mechanical protection, where space is at a premium, and when a large number of wires interconnect major electrical equipment areas. It becomes practical from structural and weight-saving considerations when 40 or more wires are called for in a cross-section. This type of rigid cable assembly is exactly defined, accurately located, and fabricated in the same shape for each assembly, whether first or last in the production run.

**EDITOR'S NOTE:** Data on mechanical layout and protection of wiring have been included in these earlier articles:

**3-D Harness Wiring,** Apr 18 '60, p 82—Presents a punched card system and three-dimensional mockups to bring mass production to custom wiring.

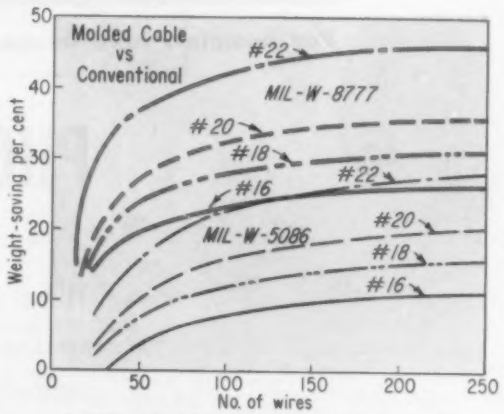
**For Best Results with Printed Wiring,** Apr 4 '60, p 57—How to determine if etched laminates will be better than conventional wiring; specific design problems faced with printed circuit boards.

**Electrical Connectors,** Dec 7 '59, p 71—Direct comparisons of all connection methods, permanent and separable.

**Punched Cards—Answer to Wiring Woe,** Jan 20 '58, p 58—Shows how computers can predict the most economical routing when connections are too numerous for a designer to figure out without help.

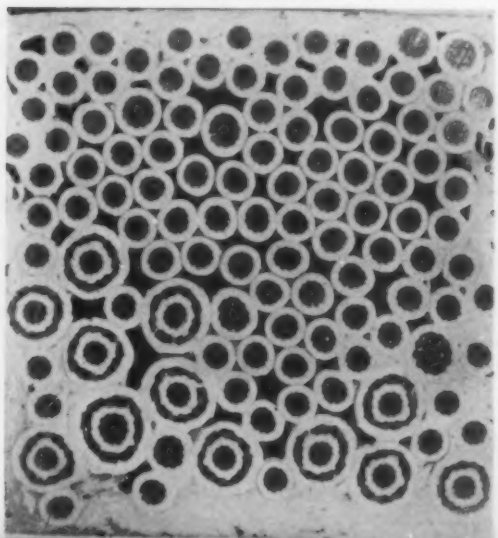
**22 Clamps for Wire and Cable,** Oct 26 '59, p 80—Shows all ways to bundle and attach electrical wiring.

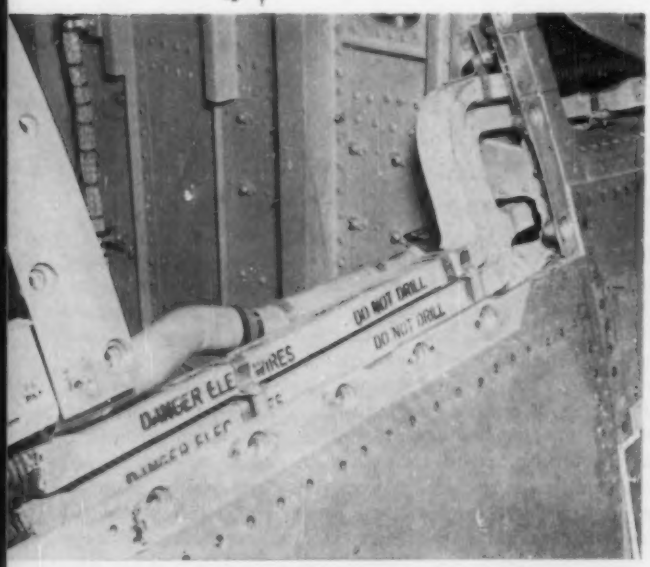
**26 Ways to Cut Wiring Costs,** June '50, p 140—Gives tips on color-coding, wire-less drawings, preformed conductors and snap-type cable clips.

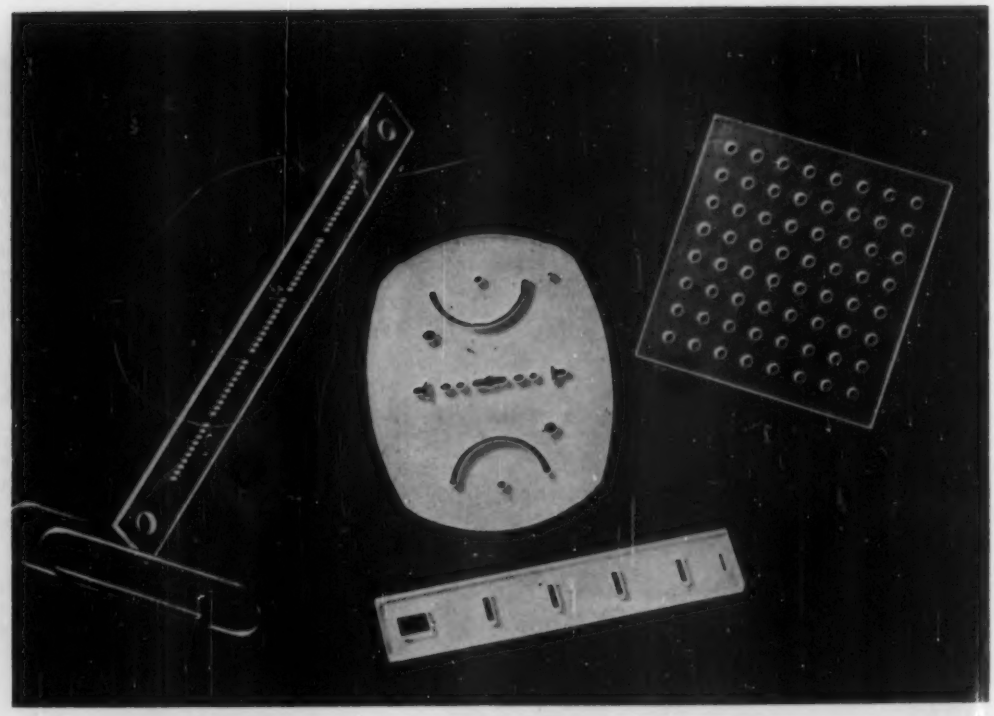



**WEIGHT-SAVING** of the hard harness is substantial for assemblies made to MIL specs.

**SECTION** of typical assembly (5 times actual size).







**For complex, hard-to-shape glass parts like these, try . . .**

# PHOTOSENSITIVE GLASS +

*Where your pattern allows light to strike this special glass it becomes extra-soluble in etching acids—an economical way to turn out electrical and mechanical precision parts.*

**NICHOLAS LAZAR,** *senior product engineer*
*Electronic Components Dept, Corning Glass Works*

When you select a glass—or one of the new glass-ceramics—as an engineering material, it's usually to satisfy a need for good electrical insulation properties, dimensional stability, and high-temperature resistance, along with chemical inertness and optical transparency. But this combination of properties is useless unless the glass can be fabricated into parts—particularly if they are the precision parts required by miniaturized design. Here, chemical machining—using photosensitive glass—is providing the answer.

Photosensitive glass contains ingredients capable of forming permanent, three-dimensional images in otherwise clear glass. A cloudy image is formed throughout the thickness in areas that are exposed to light through a photographic negative. This clouded part of the glass is much more soluble in hydrofluoric acid than the clear unexposed areas, and can be etched away

**TABLE I—PROPERTIES OF PHOTOSENSITIVE GLASS**
(Corning No. 8603, Types B and C)

| | Property | Uncerамed Type B | Uncerамed Type C | Ceramed |
|---|---|---|---|---|
| MECHANICAL | Specific gravity | 2.36 | 2.37 | 2.46 |
| | Modulus of rupture, psi × 1000 (Abraded samples) | >8.7 | >16.0 | >20.0 |
| | Modulus of elasticity, psi × $10^6$ | 11.0 | 12.0 | 13.5 |
| | Modulus of shear, psi × $10^6$ | 4.6 | 5.1 | 5.7 |
| | Working tensile strength, psi × 1000 | 1.0 | ..... | 3.0 |
| | Knoop hardness, kg/sq mm (100 gm) | 507 | 566 | 581 |
| | Softening temperature, °C | ..... | ..... | 700 |
| | Specific heat, cal/gm-°C at 25 C | ..... | ..... | 0.209 |
| | 200 C | ..... | ..... | 0.256 |
| | Thermal conductivity, cal/sec-$cm^2$-°C per cm at 25 C | ..... | ..... | 0.0056 |
| | 200 C | ..... | ..... | 0.0050 |
| | Surface finish (as formed), microinches | ..... | ..... | 80–120 |
| | Poisson's ratio | 0.20 | 0.18 | 0.20 |
| ELECTRICAL | Power factor, at 1 mc and 20 C | 0.005 | 0.003 | 0.006 |
| | 1 mc and 200 C | 0.130 | 0.021 | 0.014 |
| | Dielectric constant, at 1 mc and 20 C | 6.5 | 5.7 | 5.6 |
| | 1 mc and 200 C | 8.3 | 6.3 | 6.3 |
| | Dissipation factor, at 1 mc and 20 C | ..... | ..... | 0.0062 |
| | Loss factor, at 1 mc and 20 C | 0.033 | 0.017 | 0.034 |
| | Dielectric strength, volts/mil | ..... | ..... | >450 |
| | Surface resistivity, ohms/sq mm Untreated surface | ..... | ..... | $>10^8$ |
| | Silicone-treated | ..... | ..... | $>4 \times 10^{12}$ |

# CHEMICAL MACHINING

completely (or partially), leaving a finished part with contours completely determined by the imposed image.

Photosensitive glass comes in any of several forms: Type B is the clear unexposed type, Type C is yellow-brown in color, Type E is opaque brown to black. All are readily etchable during processing after exposure to light and heat. Type C, produced by controlled light and heat treatment of Type B, is sometimes used simply for its high electrical resistivity and its opacity. The black form of Type E finds application in photosensitive devices.

These forms of photosensitive glass contain special nucleating agents which, together with further heat treatment, function to transform the material's structure from an amorphous glass to a crystalline glass-ceramic (PE–Mar 17 '58, p 87, "Glass-Ceramics Go Commercial"). The new material has higher strength, melting point, and cofficient of thermal expansion. To distinguish between the two basic structural states of photosensitive glass, the unceramed group (Types B, C and E, above) has been termed Fotoform glass, while the ceramed form of these materials is called Fotoceram. Table I compares the mechanical and electrical characteristics of the unceramed and ceramed types.

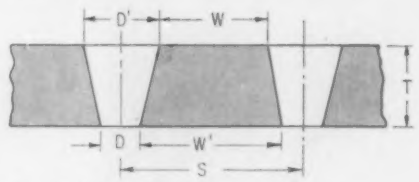
**Making the Part**

Accuracy obtained in a finished part depends primarily on workmanship in preparing the master pattern to be etched and on close process control. The designer has control only over the first of these. Art work for hole and cutout patterns is usually done in India ink on Mylar. Where possible, art work is drawn several times the size of the finished product, and reduced photographically to obtain best possible accuracy on the finished working negative. It is essential here to use premium photographic materials and technique. Neatness and accuracy on both art work and negatives are prime requisites. Occasionally, art work is adjusted to compensate for slight shrinkage of the glass that takes place during the process. This is necessary only when the part has a length-to-width ratio exceeding 2, and arises only because the long dimension requires additional support–thus slightly restraining free shrinkage.

Etching produces a hole or cavity with a side-wall taper of about 4°. When the blank is etched from one side only, with a resist material protecting the other side, a conical hole shape results. With two-sided etching, holes generally have an hourglass shape. Table II gives the limiting dimensions for holes made by one-sided and two-

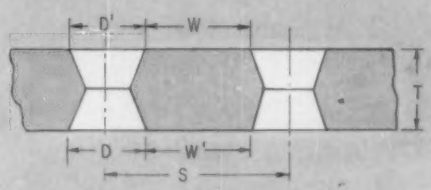
**TABLE II—ALLOWABLE DIMENSIONS FOR ETCHED HOLES**

1. One-sided Etch




Min D = T/8 or 0.010 in., whichever is larger
Max T = 8 D or 0.235 in., whichever is smaller
Min W = 0.004
D' = D + T/10
Min W' = 0.004 + T/10
Min S = D + 0.004 + T/10 (for D = T/8)

2. Two-sided Etch



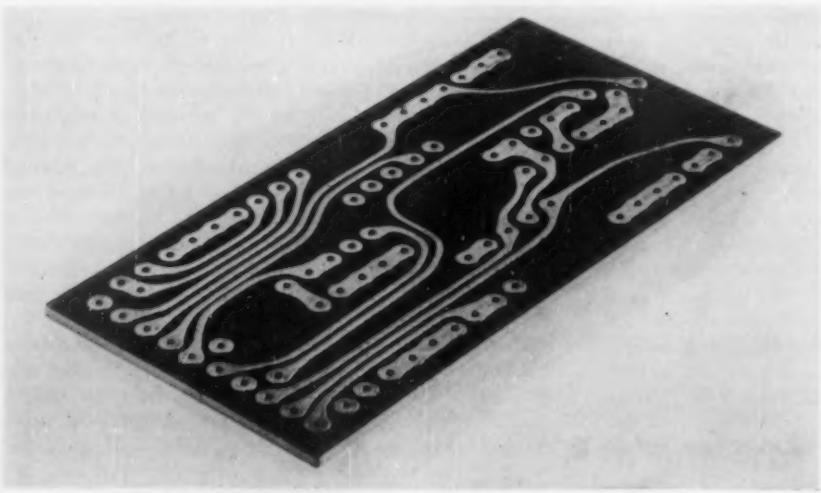

Min D = T/10 or 0.010 in., whichever is larger
Max T = 10 D or 0.235 in., whichever is smaller
Min W = 0.004
D' = D + T/20
Min W' = 0.004 + T/20
Min S = D + 0.004 + T/20 (for D = T/10)

**TABLE III—TOLERANCES FOR PHOTOSENSITIVE GLASS PARTS**
(Corning No. 8603, Types B and C)

| Dimension (all ± tolerances, in inches) | Unceramed | Ceramed |
|---|---|---|
| Cut edge | 1/16 | 1/16 |
| Ground edge (standard) | 0.005 | 0.005 |
| (premium) | 0.002 | 0.002 |
| Etched edge 0 to ½ in. long | 0.002 | 0.003 |
| over ½ in. long | 0.003/in. | 0.005/in. |
| Hole ID, and slot length (or width) | | |
| 0 to 1 in. | 0.003 | 0.005/0.007* |
| 1 to 3 in. | 0.005 | 0.010/0.015* |
| Hole spacing (center-to-center) | | |
| 0 to ½ in. | 0.002 | 0.003 |
| ½ and over | 0.003/in. | 0.005/in. |
| Out of flat | 0.002/in. | 0.005/in. |
| Pattern concentricity | | |
| exposed separately | 0.006 | 0.006 |
| exposed simultaneously | Same as hole spacing tolerances | |

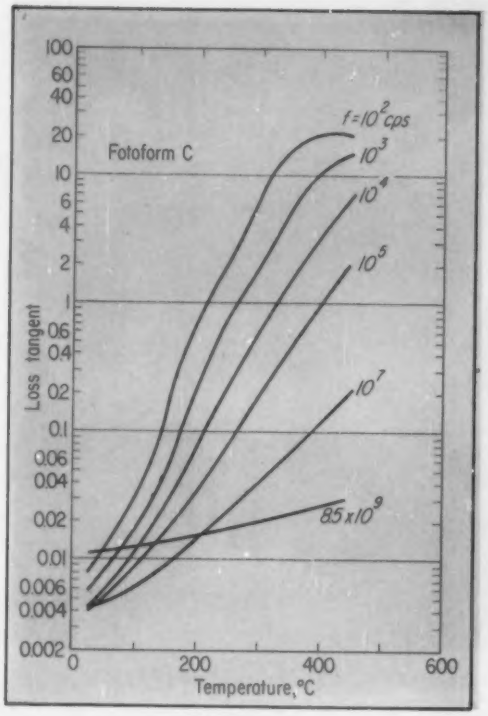
* For glass thickness up to 0.080 in./for glass thickness over 0.080 in.

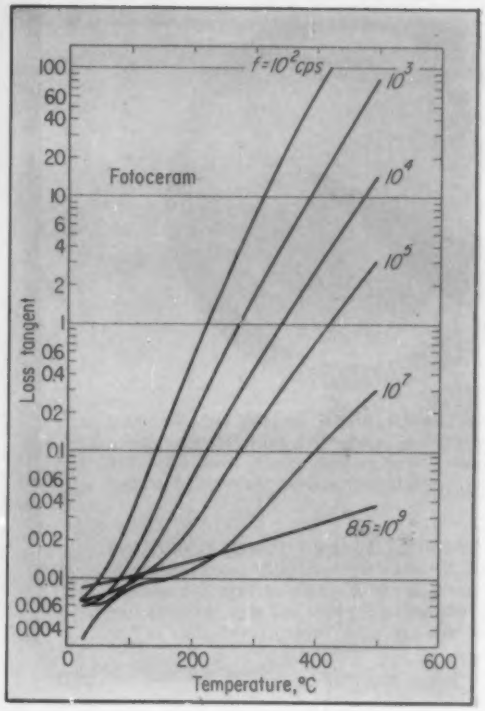
**ELECTRICAL CHARACTERISTICS** of ceramed and unceramed photosensitive glass are sharply influenced by temperature and frequency, as shown in these curves for dielectric constant and loss tangent. Note that the ceramed material is suitable for operating temperatures up to 500 C, and that at very high frequencies both electrical properties are stable over the full temperature range. Temperature limit for the unceramed glasses is about 400 C.



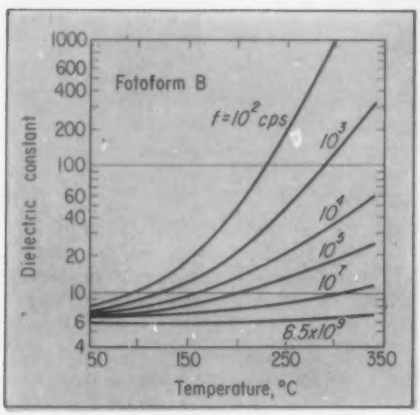
**PRINTED CIRCUIT BOARD** made of ceramed photosensitive glass has connector holes etched from both sides and through-metallized for efficient junction with the circuit pattern. Ceramed form has higher flexural strength, allowing simpler support systems to be used. Vibration tests show 1/16 in. thick Fotoceram board will withstand deflections equal to its own thickness over a range of frequencies from 10 to 2000 cps. This performance requires corner mounting on Lucite pins with fiber or rubber washers for cushioning.

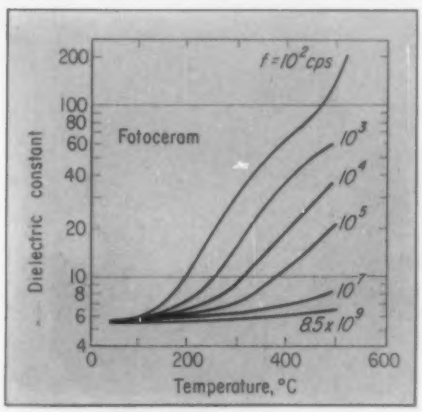
**Loss Tangent**




**Dielectric Constant**



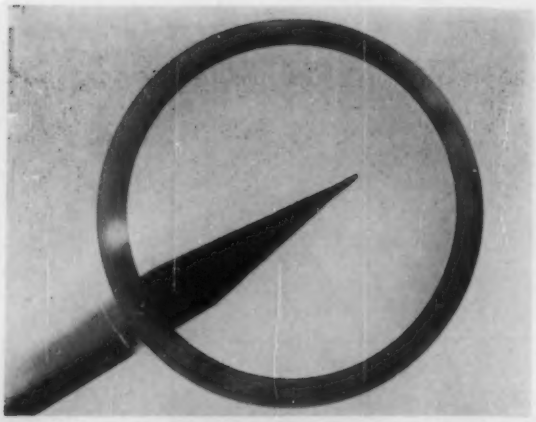




sided etching, and Table III shows the tolerances to which these dimensions can be held. Note that in most cases the unceramed material can be etched to closer tolerances. Certain parts, like soldering jigs and fixtures, and evaporation masks, can be made to even closer tolerances. In addition to through holes and slots of various shapes, relief patterns, grooves and shallow holes can be cut by selective etching and masking techniques.

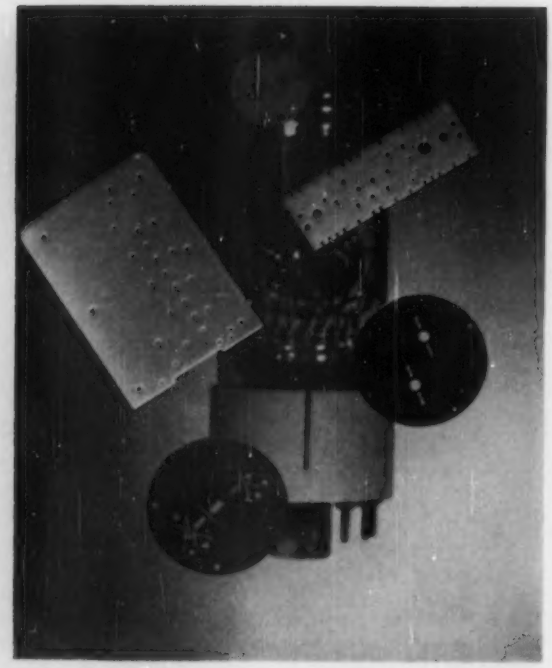
### Which Type of Etch?

Two-sided etching is generally preferred for three reasons: smaller, closer spaced holes are possible, the hourglass hole shape facilitates insertion of metal parts from either side, and electroless metallizing of the hole for printed circuit work is made easier. This last point is most important. Etching from both sides blends both edges of the hole smoothly into the surface of the flat stock, whereas one-sided etching leaves one sharp edge on the side that was masked. The smooth continuous surface from flat side to hole interior allows dependable through-hole metallizing.

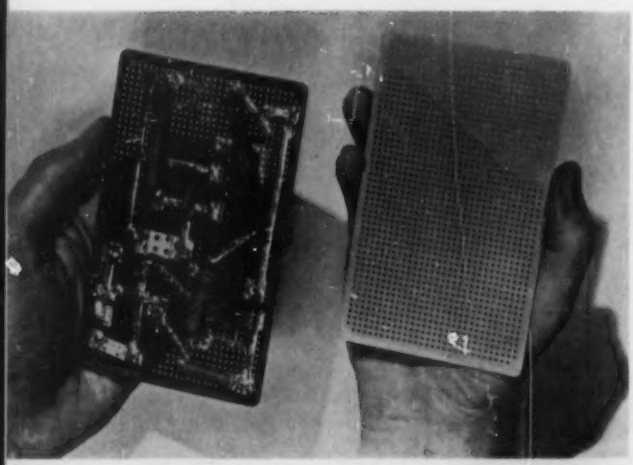
With special metallizing techniques, a uniform and continuous circuit run can be laid down on Fotoceram without the use of adhesives. Such a printed circuit, connecting integrally to through-hole metallizing, provides not only good electrical conductivity but also excellent



**GLASS SCREEN, ETCHED WITH 562,500 HOLES PER SQ. IN.,** shows fine detail possible with chemical machining of photosensitive glass. Such screens, made from very thin Fotoform, are used in electronic storage tubes and image orthicon tubes.



**PHOTOMULTIPLIER TUBE CONTAINS FIVE SPACERS** chemically machined from Fotoform B and E (dark parts). Dimensions and tolerances for hole and slot patterns like these are given in Table II and III.



**PRINTED CIRCUIT GRID BOARD** for prototype work is made from Fotoceram, with holes chemically machined. Board has all surfaces copper-clad (right). Acid etches away undesired copper to leave desired pattern (left).

thermal conductivity in dip-soldering applications. Through-hole metallizing conducts heat well, so it warms quickly, wetting properly with the solder to form a smooth, continuous fillet.

Surface finish of etched parts can be either etched or ground, depending on the application. Grinding generally leaves sharp edges on finished parts. Where necessary, grinding can be done to close tolerances, with surface finishes ranging from 120 microinches down to approximately 0.6 microinches.

Exposure, treatment and etching processes of the photosensitive glass materials discussed here are proprietary with the Corning Glass Works; these materials are therefore not yet available except in finished products made to customer specifications. An execption is a printed circuit grid board made of Fotoceram, which is available as an off-the-shelf item for prototype work in circuitry. Stock thicknesses for all materials range from 0.052 in. min to 0.235 max; and max size, so far, is about 10x12 in.

**REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 w 42nd St, New York 36, NY.**

**EDITOR'S NOTE:** Other articles on new industrial uses for glass and the glass-ceramics include the following:

**Which Process for Fiberglass-reinforced Plastic Molded Parts,** Jan 11 '60, p 47—Up-to-date guide to selecting from 15 available processes. Compares advantages and disadvantages, and shows how to choose logical one for commercial-volume applications.

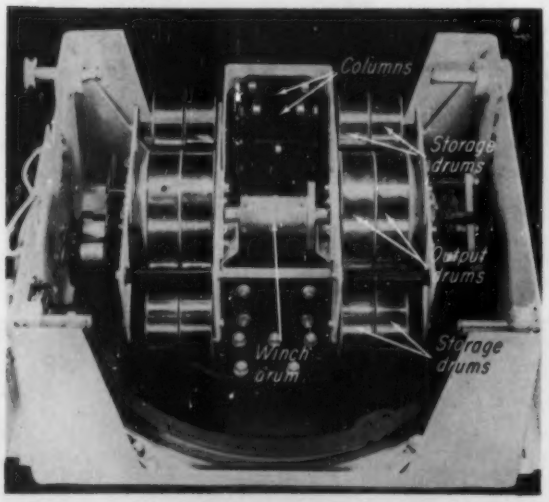
**Glass Ceramics Go Commercial,** Mar 17 '58, p 87—Application data on Pyroceram grades which show good promise for ballbearings and pistons for internal combustion engines.

**Glass Cast Process,** Oct 14 '57, p 69—New development in investment casting technique that improves strength and ductility of cast parts, reduces hand finishing, increases productivity.

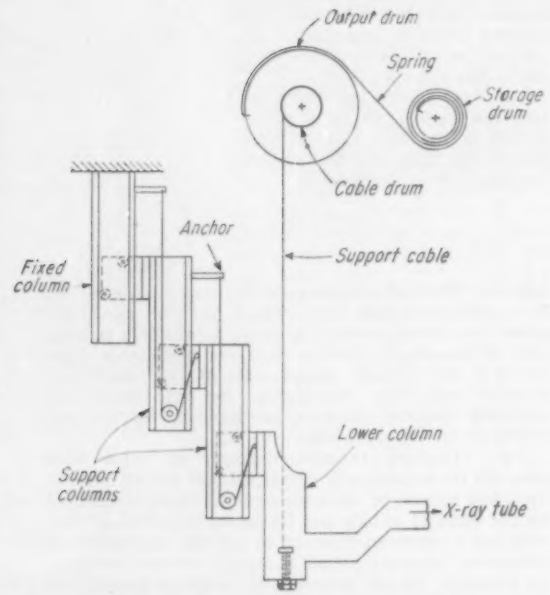
**Glass-to-metal Seals,** Jan '57, p 188—Design factors that influence selecting the best way to avoid gasketed glass assemblies.

# Balance Springs Position X-ray Safely

Counterbalanced mast permits accurate vertical adjustment of X-ray by hand. Spring motors replace the motor drives, controls and safety devices usually required.




**FOUR OUTPUT DRUMS** are used to balance the 96-lb X-ray head. Each is driven by its own three motors consisting of spring and storage drum. Each spring exerts 8 lb—therefore the 12 springs exactly balance the 96 lb load. Operator need only overcome the friction in the motors and columns (approximately 5 lb) to move the X-ray head up or down.




**COUNTERBALANCE** operates through a winch and cable-storage drum mounted overhead. Winch drum is mounted on the single output shaft of the spring motor. Constant restraining torque applied to the winch drum supports the weight of the telescoping columns and the X-ray tube. Spring motor consists of a spring wound on a storage drum, free to rotate, and then extended and anchored to an output drum. Resisting force of the spring, when wound against its natural curvature on the output drum, produces a torque about the axis of the output drum.

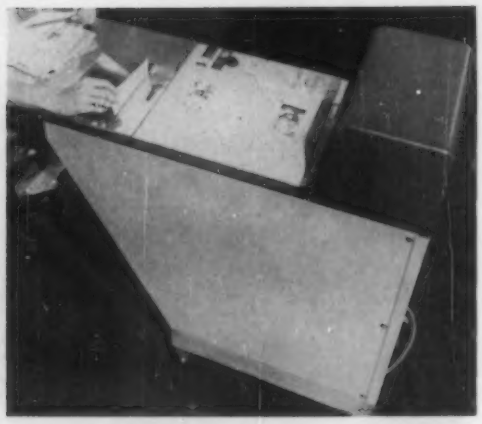
The lower column is supported by cables to the winch drum. A secondary cable attached to the top of the lower column runs under a pulley in the lower support column to an anchor in the upper support column. This cable system causes the support columns to raise or lower at ½ the speed of the lower column.

**PS . . .** Vertical movement of telescoping X-ray column is usually controlled by a motor in the overhead housing. Despite safety devices this introduces possibility of injuring the patient or X-ray tube by over-extending the mast. Manually positioned columns are produced by Kelekot X-Ray Corp, Waltham, Mass. Constant-torque spring motors are Negators produced by Hunter Spring Co, a division of American Machine and Metals Inc., Lansdale, Penna.

PRODUCT DESIGNS

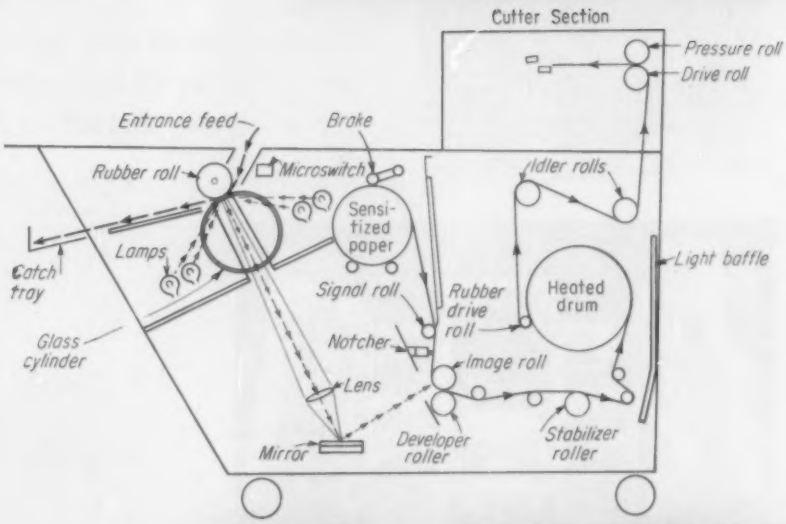
# Copy Camera Rolls to the Job

Auto headlight bulbs and a glass pressure cylinder simplify the optical system here. Copies are automatically developed and stabilized inside the same cart—no need for an outside water source.



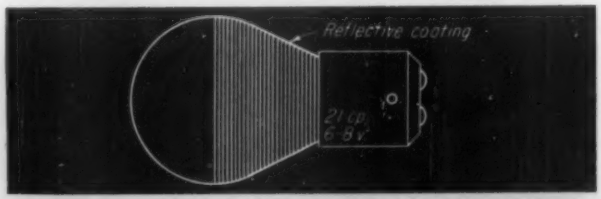
**ORIGINALS ARE FED** into the camera and pass through an exposure area. Here, the image reflected from their surface passes through the glass cylinder, which provides one half of the contact "nip," and then through a reducing lens. Reflected by a mirror, the image is projected to photographic paper moving in synchronization with the originals. The exposed paper is immediately developed, stabilized, and dried; and the copies are cut apart.

The light source and drive motors are turned on by a microswitch in the feed slot. A time-delay relay holds the light on long enough to scan the original.

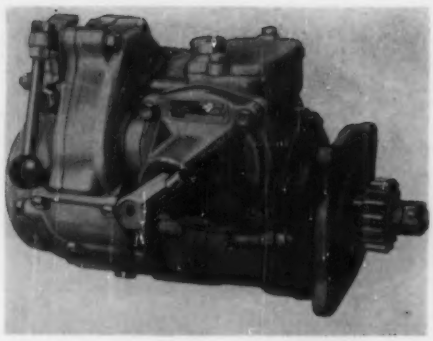



**LIGHT SOURCE** consists of 20 standard 6-8v, dc, 21-cp auto headlight bulbs which have an additional reflective coating around the neck. One row is on each side of the glass cylinder—each row containing eight bulbs in line, equally spaced, plus an additional bulb at each end. This compensates for light travel and provides uniform illumination intensity across full width of the exposure area.

The miniature, tungsten-filament, dc bulbs were selected for a number of reasons. Light source must be switched on and off instantly several times per minute as the original enters and leaves exposure area. This requires a tungsten filament to provide instantaneous response. Intensity control is simple—voltage is varied by rheostat. Broad spectrum of tungsten filament reflects ample light from wide range of colors possible on originals.

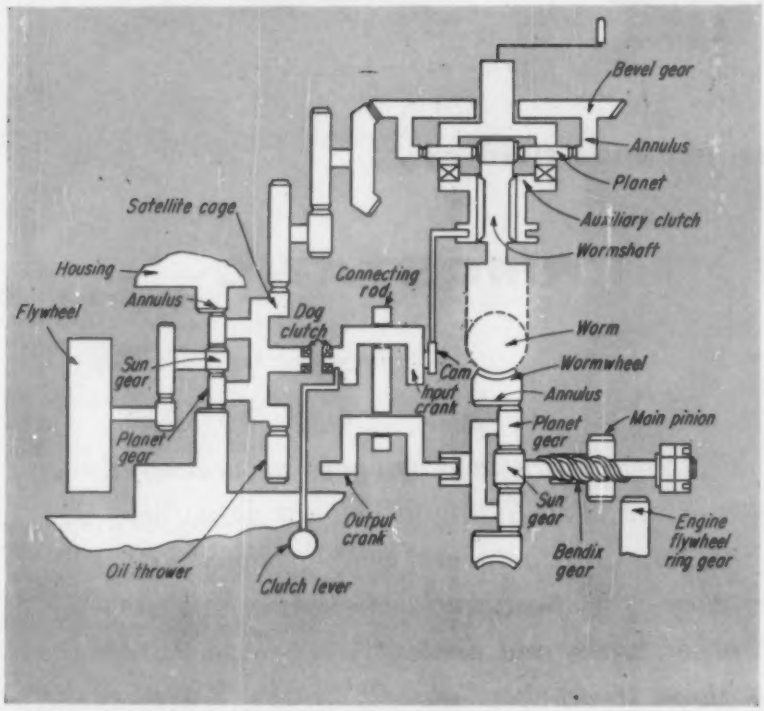


**PS . . .** Camera handles opaque originals up to 9 in. wide, of any length. Copies are reduced to 70% of their original linear size. Uses standard stat-camera photosensitized material in rolls up to 350 ft long. Only external connection required is 110-v, 60-cycle, 15-amp current source. "Copy Cart" is produced by Peerless Photo Products Inc, Shoreham, Long Island, NY.



# Cranked Engine Starts Smoothly

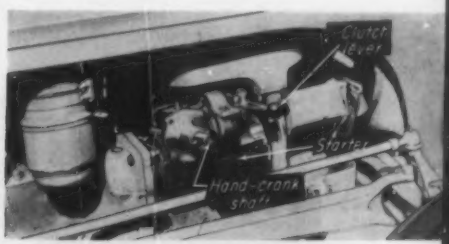
This hand starter stores kinetic energy in small flywheel that starts large diesels within ten seconds. Meanwhile, auxiliary gear train frees engine for a smooth start.




**BEFORE FLYWHEEL ACCELERATES,** the crank is also turning the engine flywheel slowly—by means of the worm and wheel. At first, it rotates the worm wheel and main-pinion shaft. Restrained from rotating by a ratchet disk, the main pinion moves along its shaft axially. It meshes with the engine flywheel ring gear and, at the end of the shaft, is forced to rotate. This is when it overcomes the ratchet disk and starts to rotate the engine flywheel slowly.

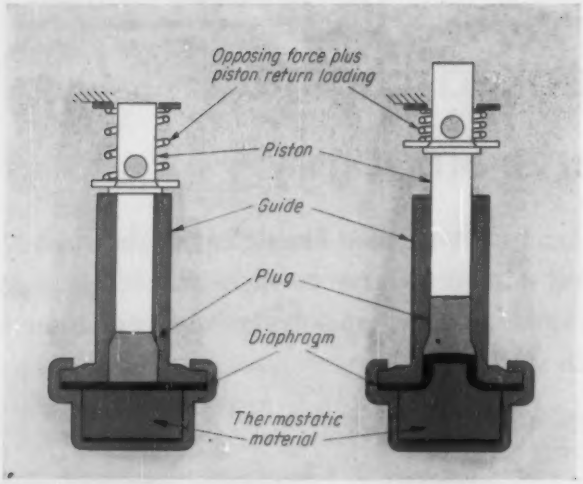
When the starter reaches operating speed through its step-up gearing from the hand crank, the dog clutch is tripped, connecting it to the engine input crank. This crank is one of a pair whose output side is connected to the pinion shaft through an epicyclic gear train. The cranks turn 180°, accelerating the starter pinion gradually as the energy in the flywheel is transferred to the engine. When engine starts, the ring gear speed is greater than speed of the starter pinion, so the latter is now pulled out of engagement by the bendix gear.

The flywheel-to-engine cranks are reset to starting position after hand crank moves pinion into mesh by means of the auxiliary worm and bendix gear. At this point engine inertia holds the pinion still, inertia of the input-output cranks is overcome, and they are reset to starting position. Once reset, they cannot move further and the drive is transmitted through the pinion to rotate the engine. Until the main pinion is engaged and the cranks reset, the auxiliary clutch stays disengaged; inertia of the step-up gearing holds the bevel wheel stationary and converts the gear set into a reducing epicyclic. With the auxiliary clutch engaged, the gear set is locked and the step-up gears driven by the bevel gear can accelerate the starter flywheel.




**OPERATOR CRANKS** the starter handle until an audible signal tells him that operating speed of the flywheel has been reached. Operator now stops cranking and engages a dog-clutch that relays energy from the flywheel to the engine. The signal is a buzzing sound produced (at 8000 rpm) by a weight with which the flywheel strikes its cover. Cranking energy is transmitted through speed-increasing gears (116:1 ratio) to the flywheel. Meanwhile, auxiliary worm shaft slowly rotates the engine flywheel to overcome initial inertia, prime the fuel injectors, and take up backlash.

PS . . . Starter weighs 73 lb, can replace electric units on diesels with up to 6-liter displacement. Developed for engines that are infrequently used but must start instantly when required, this auxiliary eliminates need for storage batteries or other electric source. Produced by Simms Motor Units, East Finchley, London, Eng




**solid-liquid phase wax expands field of . . .**

# HIGH-FORCE THERMOSTATIC ACTUATORS

*Versatile wax-filled thermal controls are now competing successfully with conventional liquid- and gas-filled bulb-and-bellows actuators. They are available from several manufacturers, with a choice of thousands of performance characteristics. Authors explain how they work, compare them with other types, and present design guide for putting them to work.*

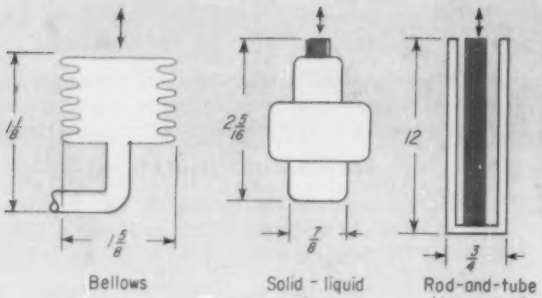
**JOHN S FREISMUTH,** *project engineer, and*
**JACK K GOULD,** *manager, product planning (Vernatherm)*
*Detroit Controls Div*
*American-Standard Corp, Detroit*

If direct mechanical output is needed from a temperature-sensing device, then a conventional electrical-contact thermostat won't do. Available for such tasks, however, are thermostatic actuators—thermostats that perform work without need for external power.

A relative newcomer to this field is the solid-liquid phase thermostatic actuator (its mode of operation is sketched above). It gets its output movement from a hydrocarbon wax, which expands considerably when it melts. The two older types—still going strong—are the thermal bulb (bulb-and-bellows) and rod-and-tube (bimetal) thermostats. All three types give axial movement.

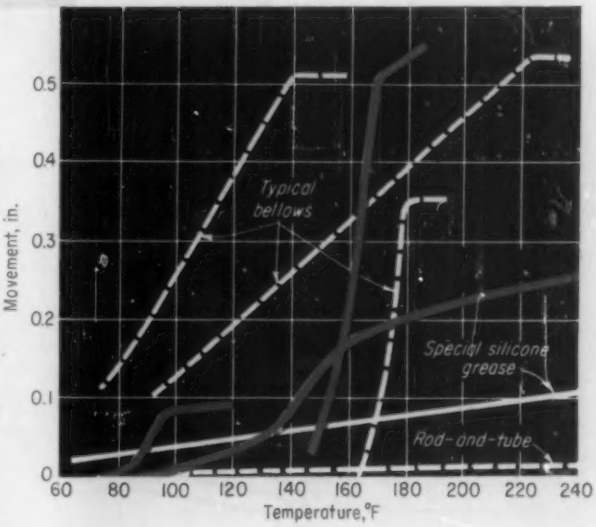
Of the three types, only the solid-liquid actuator has both large force (up to several hundred pounds) and appreciable displacement (up to 0.5 in. available, and can be larger) in a relatively narrow temperature range. Internal pressures can be high—up to 4000 psi and higher for special applications. A bellows offers larger movement, but output force will be much less, limited by those pressures which can be sustained by its flexible walls. Rod-and-tube

**TYPICAL PERFORMANCE** of Three Actuator Types (for 20-F temperature change)




| | Bellows | Solid - liquid phase | Rod-and-tube (two metals) |
|---|---|---|---|
| Output force, lb. | 13 | 37 | over 100 |
| Travel, in. | 0.35 | 0.34 | 0.001 |

**TYPICAL RESPONSE CURVES** (below) for the three types of thermal actuators (left) emphasize their different travels with changes in temperature. Wax-type elements (colored curves) have steep slope (up to 0.1 in. per °F possible in some designs) in working range, relatively flat slopes beyond this range. Silicone grease can be used instead of wax to get response shown. Bellows have nearly linear movement, with varying slopes depending on fluid in thermal bulb. Rod-and-tube element also has linear movement with temperature, but has extremely small stroke, very high force.




thermostats develop much higher forces, but depend on differential thermal expansion between rod and tube, thus severely limiting possible travel.

## HOW THE WAX TYPE WORKS

Temperature-responsive element in a solid-liquid actuator is usually a hydrocarbon wax (available from petroleum companies as a byproduct of their cracking processes). It starts melting at a given temperature, which can be different for each composition of wax and filler, and goes through gradual transition from solid to liquid—increasing significantly in volume—as the temperature rises. This change may occur in a range as little as 5 F or as much as 100 F. Typical range is 10 to 20 F. In laboratory experiments, a 1-F range has been achieved.

Copper particles dispersed uniformly in the wax improve thermal conductivity. They also help vary amount of expansion with temperature; less expansion results if more particles are added, because particles displace some of the wax.

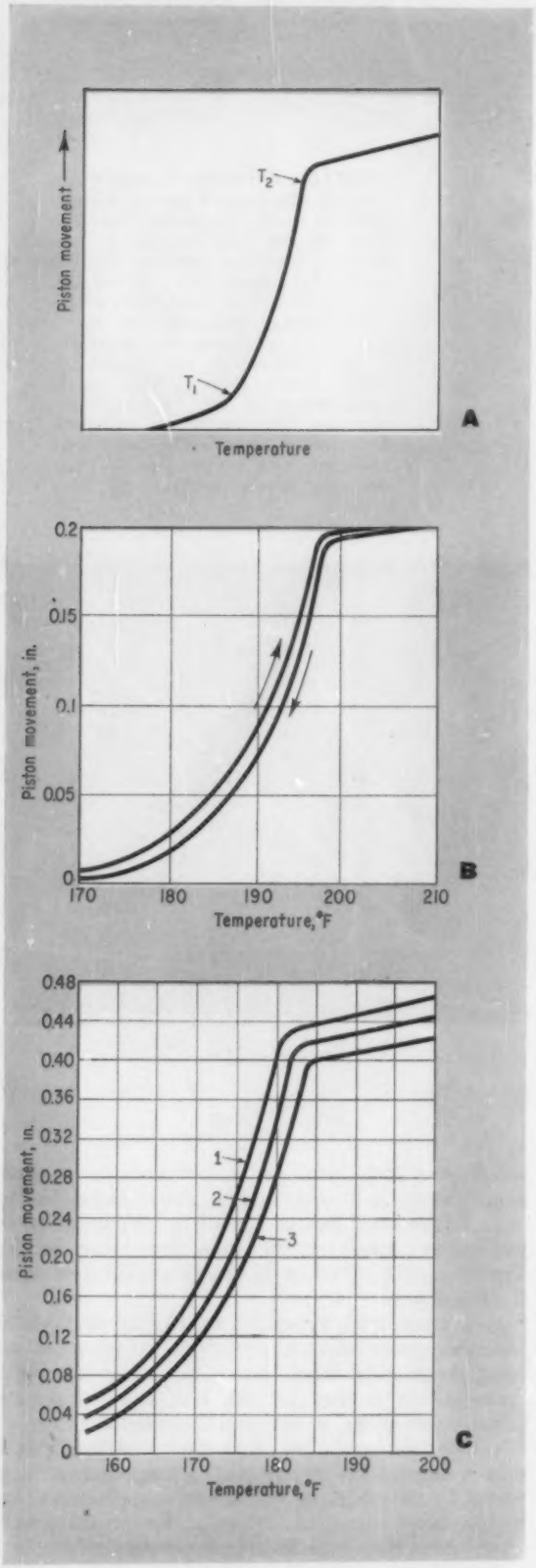
Mechanical output is the movement of the piston. A large variety of displacement-vs-temperature characteristics —several thousand are already available from various manufacturers—are made possible by changing the composition of the wax, the wax-to-copper ratio, and modifying the shape and size of the container and piston. Table and graph on this page give general data on typical designs.

To prevent loss of wax during piston movement, a diaphragm is needed. Ordinary O-ring and V-ring seals are unsuitable because wipe-by causes loss of wax tending to adhere to cylinder walls. The rubber plug transmits motion and pressure from diaphragm to piston—without damaging diaphragm as a mechanical link might do. And necking-down of the plug's surrounding walls allows magnification of the motion.

Return motion of actuator (during cool-down) is somewhat different than forward (operating) motion. It depends on normal hysteresis in mechanical parts (base, plug, piston), and crystallization characteristics of the wax. For instance, the wax has a larger volume (at given temperature) during recrystallization than during melting. Typical travel-temperature hysteresis is plotted in chart *B* on next page.

Force-temperature hysteresis (not plotted) would show somewhat greater offset than that plotted for travel, because the friction forces reverse on return stroke and oppose piston motion, and the load supported by the piston normally stays in the same direction. For example, if a 30-lb load can be moved in the operating direction, then a larger load—several pounds more—can be supported by the piston on the return stroke because plug friction helps sustain it. However, be careful not to exceed internal pressure limitations of actuator.

Return spring is usually needed for cool-down stroke,




because wax is contracting and does not exert positive force on the diaphragm. Return spring can be eliminated if supported load can be counted on to provide return force.

## TEMPERATURE LIMITATIONS

End-point temperatures (points $T_1$ and $T_2$ on graph, this page) can be as high as 250 F, or as low as 32 F; but with the hydrocarbon waxes available, no single actuator can span the entire range.

The waxes can physically tolerate much higher (and lower) temperatures than those in the working range, but actuator response will tend to fall off at the end points. And other parts of actuator have limitations too: diaphragm is normally limited to 300 F (450 F if special material is used); excessive overtravel (out of working range) may strain or rupture diaphragm; and copper dispersion in wax may settle slightly if temperature exceeds 200 F above max working value (at normal temperatures, a rubberlike binder keeps copper dispersed).

If ambient temperatures in shipment or storage will cause excessive overtravel of the actuator, special design precautions (such as specifying load-limiting springs) should be taken. If necessary, ship your control mechanism to actuator manufacturer for proper assembly.

For special low-temperature operation (below 32 F), and high-temperature operation (up to 450 F), where hydrocarbon waxes are unsuitable, silicone-type greases can sometimes be substituted. Such grease is not a solid-liquid phase material, and has much lower thermal expansion than most of the waxes, but will give linear output throughout wide temperature range. However, its working-temperature range must be wider to produce significant piston movement.

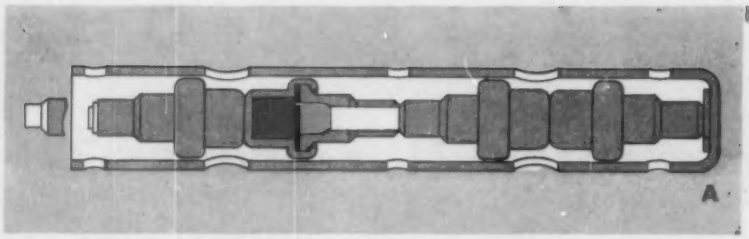
## ACCURACY AND RESPONSE

Temperature-sensing accuracy attainable with hydrocarbon-wax actuator is about ± 1 F with ideal operating

**A ACTUATOR RESPONSE** is almost linear in working-temperature range from point $T_1$ to $T_2$. Below temperature at $T_1$, hydrobarbon wax is solid; above $T_2$, it is liquid. In between, it changes gradually from solid to liquid. Range can be varied, depending on wax compound used (see typical-response curves p 75).

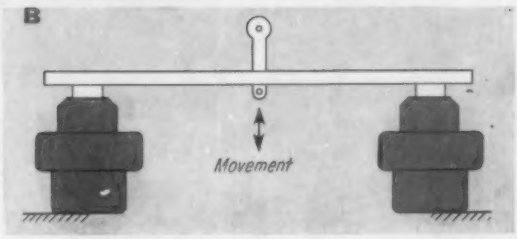
**B NORMAL HYSTERESIS** of wax and mechanical parts (see text on previous page) gives return travel that is offset about 0.01 in. from forward travel. Example is for typical spring-loaded actuator.

**C LOAD AFFECTS MOVEMENT** of any actuator (including bimetal type) because force-producing element is somewhat elastic and compressible. Curves here are for typical hydrocarbon-wax actuator working against three different test loads (compression springs): curve 1—60-lb preload, 80-lb final; curve 2—80-lb preload, 115-lb final; curve 3—100-lb. preload, 135-lb final.

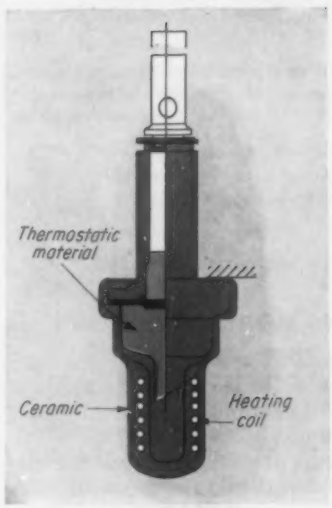



**A GREATER TOTAL MOVEMENT** for given temperature change results when identical actuators are stacked in series. Design shown has over 0.5-in. travel for 50-F change. One variation—to increase total temperature range—is to have nonidentical actuators, each designed for a different temperature, so that one actuator takes over where the previous one leaves off.

**B AVERAGE TEMPERATURE** of two actuators determines movement of center link in this design.




**ELECTRICALLY OPERATED THERMOSTATIC ACTUATOR** has hydrocarbon-wax element, but heating is controlled with electrical current. Design is useful for positioning valve remotely—a rheostat on the control panel adjusts heat input to coil. Another application: electrically operated plunger to replace conventional solenoid where high speed is not important.




conditions. An example of ideal conditions is the mixing valve shown on p 78. It has sufficient flow to assure good surface heat transfer from water to sensing element.

Accuracy is not affected by moisture, humidity or changes in pressure and elevation, because actuator cases are mechanically strong and thermostatic material is sealed in.

Positional repeatability is good—best normally attainable is ± 0.005 in. for a given temperature—and response is approximately linear in working-temperature range. The performance table on t is page shows travel tolerances for typical actuators.

Speed of response for wax-type elements is relatively slow—from about 10 seconds to as much as 2½ minutes for full piston stroke, depending on mass of unit. Internal thermal conductivity of hydrocarbon wax with dispersed copper is good, but effective heat-transfer coefficient of external surface is only fair. Best response is obtained when the fluid medium being sensed is moving at high velocity.

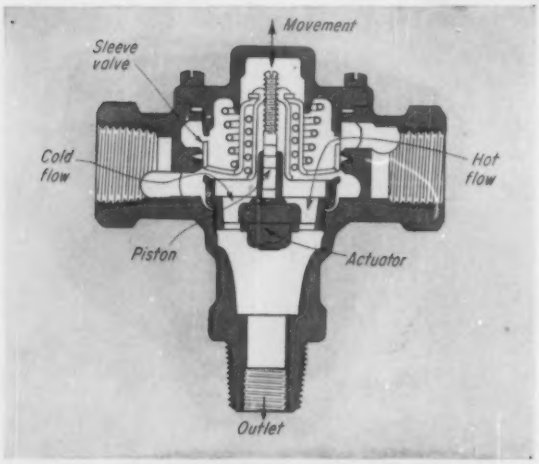
Slow response sometimes helps avoid instability, however. Piston movement will be smooth, unaffected by rapid fluctuations in temperature.

### Modifying Output Force

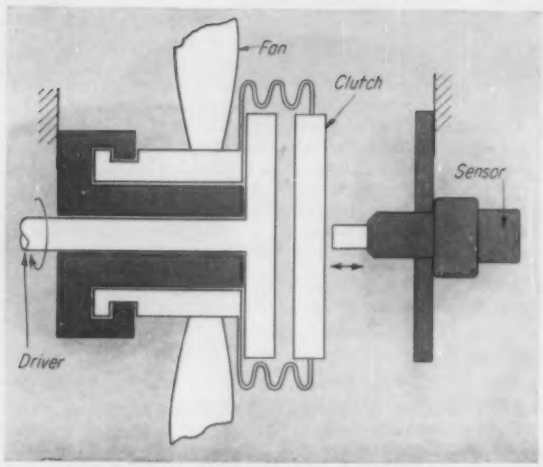
Preload springs—normally used to help return piston to cool-down position—may also be used to absorb a portion of piston output force, thus limiting force available to move the load. This feature helps prevent damage if driven mechanism is not intended to withstand high forces. Special springs such as the nonlinear type will vary this resisting force in any manner desired.

**PERFORMANCE OF TYPICAL HYDROCARBON-WAX ACTUATORS**
(test-loaded with compression spring)

| Over-all length, in. | 1 | 1⅛ | 1¾ | 2¾ | 3 | 3½ |
|---|---|---|---|---|---|---|
| Cup size, in.: dia | 0.28 | 0.39 | 0.39 | 0.91 | 0.91 | 1.37 |
| length | 0.25 | 0.25 | 0.30 | 0.33 | 0.66 | 0.59 |
| Initial: temp., °F | 200 | 180 | 80 | 180 | 70 | 150 |
| force, lb (preload) | 20 | 8 | 14 | 60 | 200 | 78 |
| Final: temp., °F | 215 | 205 | 102 | 195 | 85 | 170 |
| force, lb | 23.2 | 10.6 | 17.6 | 76 | 260 | 112 |
| travel, in. | 0.067 ± 0.007 | 0.165 ± 0.005 | 0.330 ± 0.010 | 0.335 ± 0.015 | 0.397 ± 0.012 | 0.465 ± 0.015 |




**WATER-MIXING VALVE** is typical application for hydrocarbon-wax thermostatic actuator. Actuator adjusts sleeve up or down automatically until mixture temperature of hot and cold water remains constant at set value.




**COOLING FAN FOR ENGINE** is clutched-in automatically by thermostatic actuator when sensed temperature is too high, and is declutched when temperature is too low. Between these temperatures, fan speed depends on actuator force and clutch slip. As much as 20 hp can be saved in a typical large automobile engine by declutching fan when it is not needed.

## COST AND MAINTENANCE

Initial cost of a hydrocarbon-wax actuator is less than $1 for small size, less than $10 for large size. Principal saving, however, is in elimination of external power connections: The sensor does its own work.

Service life mainly depends on diaphragm, but the hydrocarbon wax will also deteriorate somewhat after repeated cycling. Typical over-all life for actuator in a heavy land vehicle is 50,000 full-stroke cycles. Actual useful life will be much greater, particularly if cycling is less than full-stroke.

## CHOOSING AN ACTUATOR

Most thermostatic actuators are custom-designed for a particular application. There are thousands of possible variations in temperature, force and stroke so that it is impractical to stock even a small portion of them. It is important, then, to define the application in detail before writing final specifications. Here are points to consider:

### The Three Actuator Types

Bulb-and-bellows actuators are ideal for remote sensing where the bulb must be located at an awkward distance from the bellows, and where high sensitivity is needed. Rod-and-tube thermostats are commonly found in pneumatic systems—where direct and powerful mechanical axial movement of bimetal element directly positions pilot valve in pneumatic amplifier. Solid-liquid thermostatic actuators are simplest, because they are self-contained and smallest of three types for given energy output. Vibration and other ambient conditions do not harm them. They can be conveniently "stacked" (see sketches on previous page) to multiply movement or extend working-temperature range.

Sometimes, advantages of one method can be combined with those of another. For example, solid-liquid hydrocarbon wax can be used in a thermal bulb—high thermal expansion of the wax can be transmitted via oil in capillary tube to a remote piston. Also, the long slender design of a thermal bulb can be applied to the solid-liquid actuator shown on page 74, increasing surface area and considerably reducing thermal response time.

**EDITOR'S NOTE:** These previous articles discuss separate elements of the problem of temperature-sensitive actuators

**Thermal Actuator,** Nov 3 '58, p 33—Detailed description of how Freon vapor, in conjunction with electric heater and cooling coils, actuates large valve mechanism. Entire unit is self-contained.

**Automatic Temperature Control,** Sep '56, p 179—Explains operating characteristics of simple thermostats, including bimetal (tube-and-strut version) and bellows.

**Saving Space with the Liquid Spring,** Aug 17 '59, p 53—Shows how characteristics of silicone oil—including thermal coefficient of expansion—influence design of high-force liquid springs. The thermal expansion is useful in thermostats, but troublesome in liquid springs.

## Employee Gift Matching

# Another Good Way To Help Our Colleges And Universities

The business community continues to make an impressive record in giving badly needed financial help to our colleges and universities. This year the Council for Financial Aid to Education expects that business contributions to higher education will be well over four times their total of about $40 million a decade ago.

If these contributions, which were about $150 million last year, continue to increase at the present rate, they will hit the target of $500 million set for business aid to our colleges and universities in 1970. This is the amount which, the Council calculates, must come from business if these institutions are to have the money to do their job properly a decade hence.

However, it would be a fine thing both for the nation and the business community if that $500 million dollar target were hit well before 1970. This would put us ahead of a schedule (it is a conservative schedule) in getting on top of what remains one of the nation's most crucial problems—that of having its colleges and universities adequately financed which they are very far from being right now.

**There is, we believe, one quite simple way by which financial support for higher education by business firms might be considerably speeded up. All that is required is that business firms generally abandon the idea that it is possible for every company to have a program to provide such support that is novel and distinctive,** and that this is the only way that interests of prestige and good public relations can be served.

There are nowhere near enough good plans to provide financial help for higher education to equip even a small percentage of our business firms with one that is novel and distinctive. Also **there are a number of very good plans which, so far as we can tell, lose nothing of their value for prestige and good public relations by being used by a large number of companies.**

### The Gift Matching Idea

One plan with these attractive characteristics is the plan by which companies match the gifts of their employees to colleges and universities, and now increasingly gifts to independent secondary schools. So far as we can discover the general plan was invented by the General Electric Company, with what it calls its Corporate Alumnus Program. Now, with variations on the same basic design, almost 100 companies have gift matching plans. We at McGraw-Hill are included in this number.

The gift matching plans vary considerably in detail. Some are limited to alumni of the schools to be benefited. In others any employee can participate by making a gift to an eligible institution. There are also variations in the maximum amounts of gifts by individuals and to individual institutions which will be matched. Some companies have "open end" plans; others limit the total to be matched in any one year. All of the plans, however, embody the same central gift matching idea.

When the plan was first launched some college administrators of little faith in the fundamental generosity of the alumni and friends of their schools expressed the fear that if gifts were to be matched they might be made smaller in the first place. The opposing view was that the possibility of having them matched would stimulate more and larger gifts.

### Advantages Of Gift Matching

**So far as we have been able to discover, the expectation that giving would be stimulated by gift matching has been validated by the experience with the plans.** This has been our experience at McGraw-Hill. Some other important virtues of the gift matching programs have been summarized by

**LEADERS OF SOME OF THE INSTITUTIONS WHICH HAVE SHARED IN THE McGRAW-HILL EMPLOYEE GIFT MATCHING PROGRAM EXPRESS THEIR VIEWS**

*"We particularly appreciate the fact that your grant is unrestricted, and can therefore be used for our area of greatest continuing need — the General Education Fund, from which faculty salaries come."*

W. Boyd Alexander, Vice President and Dean of the Faculty
**Antioch College**

*"We are grateful, not only for the financial support given to The Cooper Union by your company, but also for the stimulus it has provided our alumni in your employ to make annual gifts to their Alma Mater."*

Edwin S. Burdell, President
**The Cooper Union**

*"The gift matching program has a dual advantage. First, it acknowledges and repays a debt of honor to those colleges which, often at great loss to themselves, have trained and educated the men who are now among your personnel. This is most fair and equitable. Secondly, by offering to match up to a given limit the contributions of alumni, you encourage support of their own colleges on the part of graduates, who themselves are so indebted."*

President Edward B. Bunn, S. J.
**Georgetown University**

*"Thanks to your doubling of the annual gifts of one of our generous and loyal friends who works with you at McGraw-Hill, we are well on the way toward creating what for us will be an extremely helpful scholarship fund. This would not have been possible without the gift matching program."*

C. Adrian Heaton, President
**California Baptist Theological Seminary**

Ernest T. Stewart, Executive Director of the American Alumni Council (1785 Massachusetts Avenue, N.W., Washington, D.C.) who would be glad to provide detailed information about them, and the names of companies having such plans. Of the gift matching idea he says,

> "*First*—it assures the corporation that its gifts go direct to those colleges and universities which have furnished it with trained manpower.
>
> "*Second*—it places responsibilities for the gifts on the institutions themselves and drives home the point that they must make a real effort with their own alumni.
>
> "*Third*—it leaves the final decision of corporate support basically to the employees."

For many companies which are fearful of complicating their relations with their customers by courting charges of favoritism if they provide direct financial support for any particular school or group of schools, this latter consideration can be of decisive importance.

The gift matching plan also has what for many companies is the very important virtue of being simply and easily administered. Some additional virtues of the gift matching plan, as seen by officers of institutions which have been beneficiaries, are indicated in the box at the top of this page.

## Effective And Easily Managed

We at McGraw-Hill are well pleased with our gift matching program. It is a broad program in which all employees and a wide array of colleges and universities, both privately and publicly supported, are eligible to participate. We commend it as an effective and easily managed plan to provide urgently needed financial aid to higher education.

**We also urge that business firms adopt this or one of a number of other very good programs of financial aid to higher education* rather than delay in the hope of hitting upon some quite new and distinctive plan. There are very long odds that such delay will prove unavailing. In the meantime our colleges will be losing financial help which it is profoundly in the interest of the business community and the nation to see that they get—and get fast.**

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*An earlier editorial in this series dealt with tuition supplements as another good way to help our colleges and universities. Reprints of this editorial are available. So are copies of a "more or less socratic dialog," entitled, **A Business Wrestling with the Problem of Aid to Colleges and Universities.** It was prompted by the efforts of McGraw-Hill to find suitable methods of providing financial aid to higher education.

*This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.*

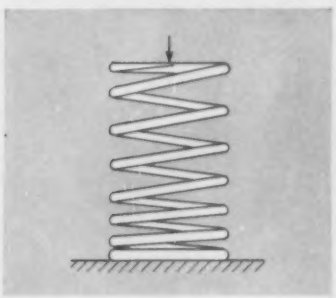
Donald C. McGraw
PRESIDENT
**McGRAW-HILL PUBLISHING COMPANY, INC.**

## SPRINGS:

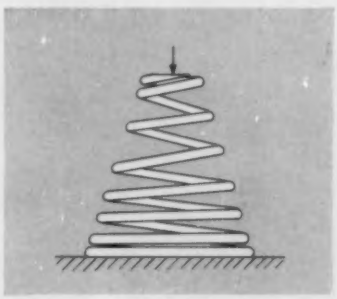
# how to design for Variable Rate

Eighteen diagrams show how stops, cams, linkages and other arrangements can vary the load/deflection ratio during extension or compression.

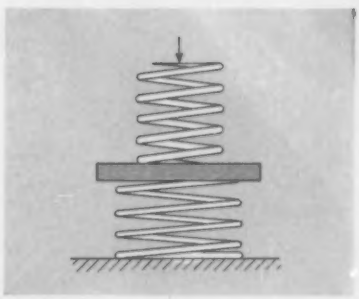
**JAMES F MACHEN,** *asst professor, mechanical engineering*
*University of Toledo, Ohio*



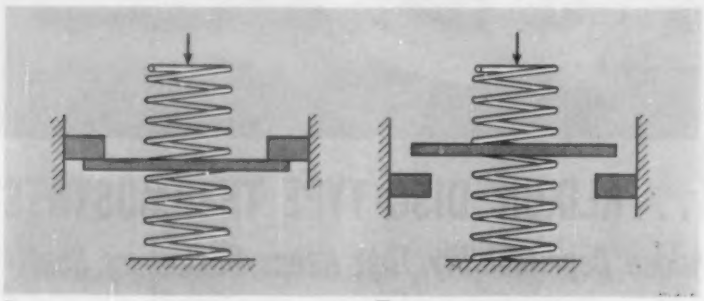
**1**
**WITH TAPERED-PITCH SPRINGS** (1), the number of effective coils changes with deflection—the coils "bottom" progressively. Tapered



**2**
O.D. and pitch (2) combine to produce similar effect except spring with tapered O.D. will have shorter solid height.

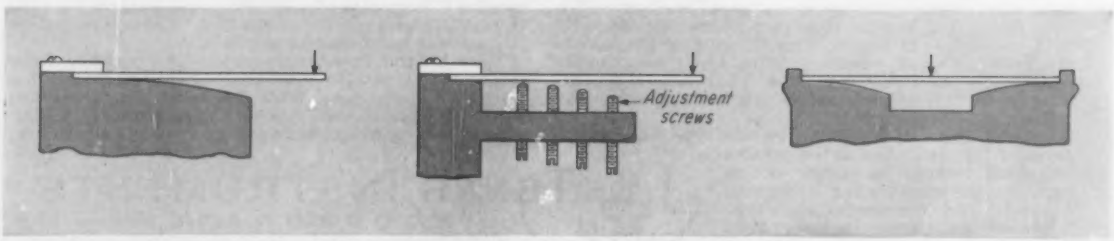


**3**
**IN DUAL SPRINGS** one spring closes solid before the other.



**4** **5**

**STOPS** (4, 5) can be used with either compression or extension springs.




**6** **7** **8**

**LEAF SPRINGS** (6, 7, 8) can be arranged so that their effective lengths change with deflection.

continued on page 83

*Where Product Reliability is Important*

# . . . KLIXON® DISC TYPE THERMOSTATS

## *Give Your New Models Added Dependability That Keeps Customers Sold*

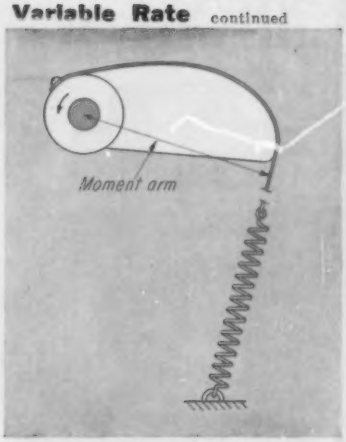
Actuated by the scientifically calibrated Spencer disc, KLIXON Fixed Temperature Thermostats "snap" the circuit open with a clean, quick break . . . "snap" it closed with a solid make. And because they have no complicated parts with knife edges or toggles, their accurate performance is unaffected by shock, vibration, altitude or cross ambients regardless of the mounting position. The result . . . dependable day-in day-out performance that helps assure greater product reliability.

KLIXON 20400 and 20600 series disc type Thermostats are ideal for application as fan switches and limit controls in electric clothes dryers, appliances, heating equipment, industrial and commercial apparatus. Their relatively small size makes them suitable for use where space is limited. They have heavy duty electrical capacity . . . up to 25 amps., 120 and 240 VAC resistive U/L approved for 100,000 cycles. KLIXON disc type thermostats are available with bottom or surface mountings . . . screw or quick connect terminals.

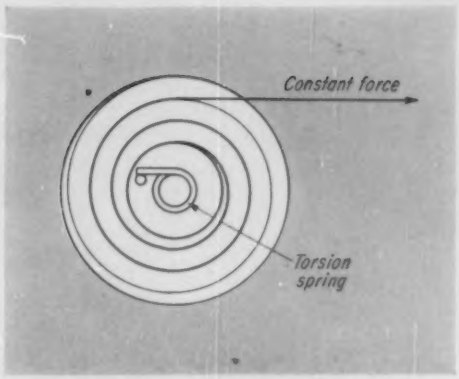
These KLIXON Thermostats are available in automatic or manual reset types. Our Field Engineers will gladly help you make test applications. Write for technical data bulletins THSN-19, THSN-23, which give complete performance characteristics, temperature setting information and dimensions.

**TEXAS INSTRUMENTS**
**INCORPORATED**
METALS & CONTROLS DIVISION
3807 NORTH MAIN STREET • VERSAILLES, KENTUCKY
SPENCER PRODUCTS
Commercial Controls Department

## Variable Rate continued

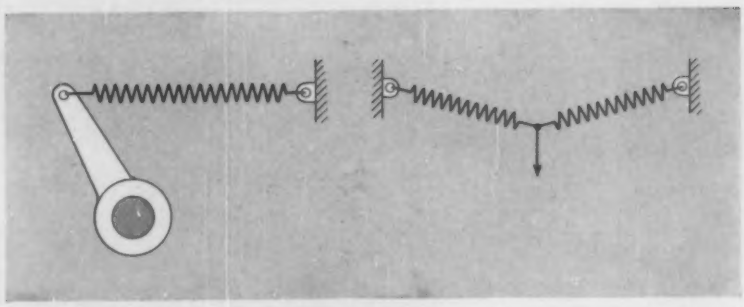



**9**
**CAM-AND-SPRING DEVICE** causes torque relationship to vary during rotation as moment arm changes.

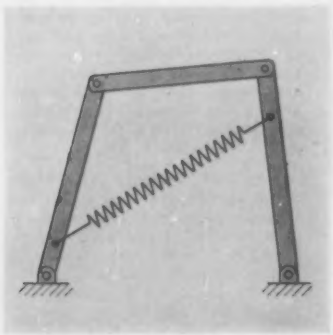



**10**
**TORSION SPRING** combined with variable-radius pulley gives constant force.

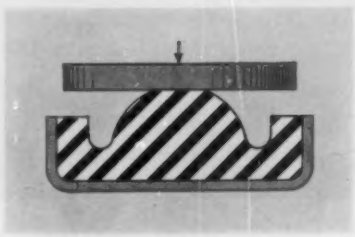
**LINKAGE-TYPE ARRANGEMENTS** (11, 12) are often used in instruments where torque control or anti-vibration suspension is required.



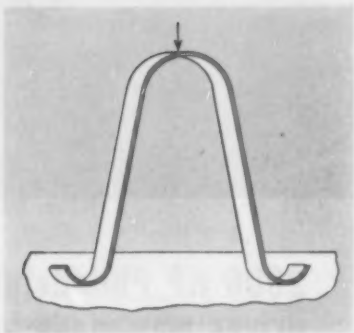
**11** **12**



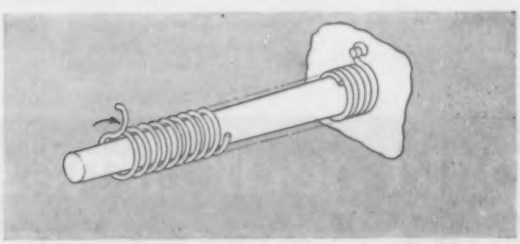
**13**
**4-BAR MECHANISM** in conjunction with a spring has a great variety of load/deflection characteristics.



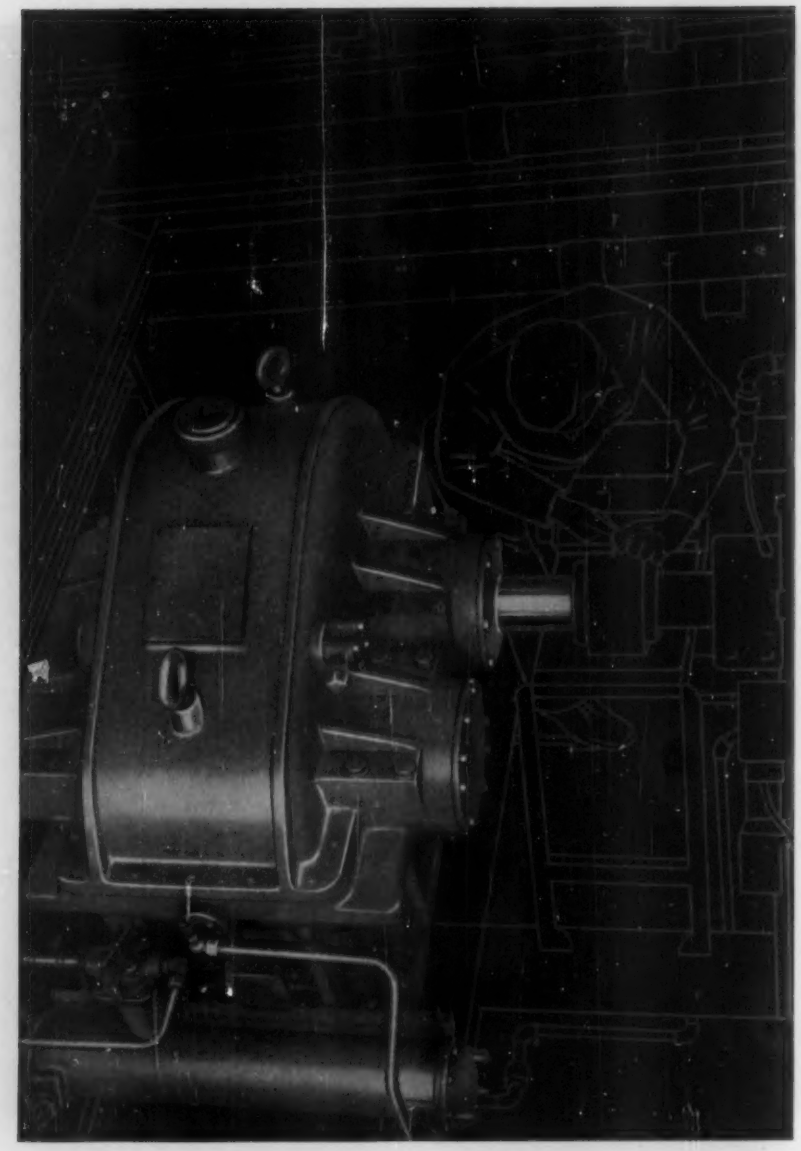
**14**
**MOLDED-RUBBER SPRING** has deflection characteristics that vary with its shape.



**15**
**ARCHED LEAF-SPRING** gives almost constant force when shaped like the one illustrated.



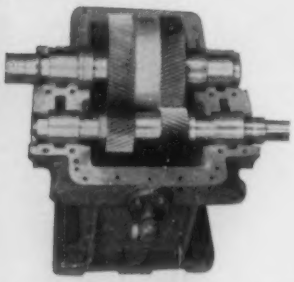
**16**
**TAPERED MANDREL AND TORSION SPRING.** Effective number of coils decreases with torsional deflection.



## 2000 HP Philadelphia HI-SPEED Increaser drives man-made hurricane . . .

Wind tunnel testing of missile and aircraft models at supersonic speeds demands exacting performance and extremes of endurance for all equipment involved. At Cornell Aeronautical Laboratory, Inc., this 2000 HP Philadelphia Increaser drives a modified jet engine compressor for developing tunnel air speeds of 600 to 1500 mph. Operation is on a continuous, round-the-clock basis . . . often for extended periods of time.

## IMPROVED GEAR ACCURACIES MEAN HIGHER SPEEDS, LESS WEAR



With today's demands for higher speeds, problems of service life become much more critical. And there is only one solution . . . more accurate gearing. Specifically, Philadelphia Gear Drives equipped with precision ground gearing.

This development is so significant you can solve drive problems you could never solve before . . . because you get engineering advantages never available in standard drives . . . at commercial prices.

Longer life is only one advantage however. Improved gear accuracies also mean significant increases in load carrying capacity. Sound levels are reduced to the point where gear noise will never be a problem, even on applications where low sound levels are important.

Precision ground gearing reduces backlash in reversing drives and provides uniform backlash where precision of movement is important. Interchangeability, too — duplicate gearing can be installed with original manufacturing tolerances duplicated . . . exactly.

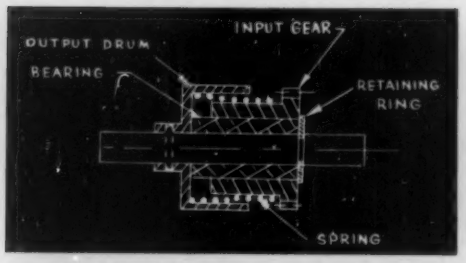
Standard Philadelphia *HI-SPEED* drives are designed for speeds to 10,000 rpm at pitch line velocities to 10,000 fpm. Horsepower ranges from 1 to 7100 HP. Ratios from 1:1 to 10:1 for high speed reduction or increase. Exact specified ratios are furnished within ½%.

Send for more information about Philadelphia HI-SPEED Increasers. Offices in all principal cities. Or write directly to:

**PHILADELPHIA GEAR CORPORATION**
King of Prussia, Pennsylvania
(Suburban Philadelphia)

**philadelphia gear drives**

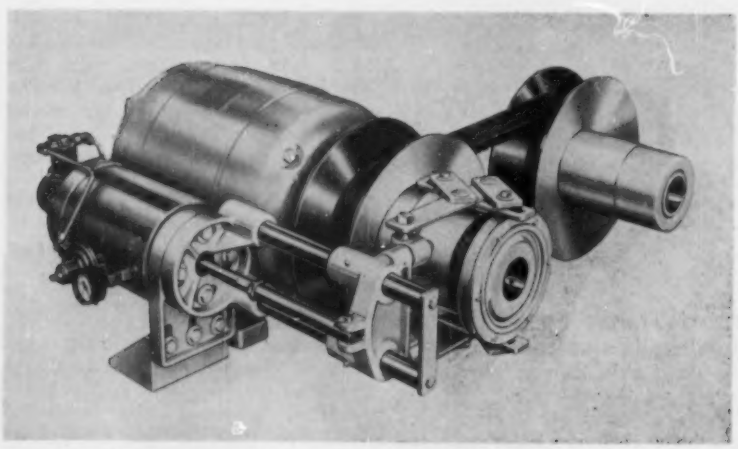
# SIGNIFICANT COMPONENTS MATERIALS, PROCESSES




## Continuous-slip clutches and brakes . . .

are suitable for use as tensioning, clutching or braking and in servosystems, mechanisms and systems. Element producing slip is a stepped spring. ID of small step fits tightly over input drum. OD of large step is assembled tightly in bore of output drum. Rotation of shaft in one direction causes coils in contact with input to grip tightly and coils inside output bore to contract and produce slip. Rotation in opposite direction reverses action of spring parts and slip is effected on input drum. Stepped-type spring clutch can be designed to have the same or different torque capacities for two directions of rotation. Torque levels where slippage occurs are independent of each other, and ratios of 10:1 can be provided. Ratios to 100:1 are available in special designs. Slip elements are said to have high power-dissipation ratings and withstand continuous slip for hundreds of hours of operation. Standard slip elements are factory-calibrated to 15% of specified limit torque. Stock elements are $18, $21 or $26 each, depending upon unit. **Machine Components Corp, Gassa Blvd, Farmingdale, NY.**

**Circle 300 on Reader Service Card**



## Pneumatic regulator . . .

automatically controls speed of variable-speed pulleys. Regulator operates from process instruments in 3 to 15-psi signal range, to obtain speeds that are varied, maintained or repeated with signal pattern. Pulleys are available in ratings to 25 hp, in speed ranges to 10:1. Adds $360 to $540 to price of pulleys. 4-wk delivery. **Lewellen Mfg Co, Columbus, Ind.**

**Circle 301 on Reader Service Card**

## Nonflammable enamel paints . . .

based on a nonvolatile chlorinated alkyd resin are available in a variety of colors for general use on metal and wood surfaces. They have passed Navy test requiring that paint films on steel panels will not become ignited upon being heated electrically for 30 sec, at which time a temperature of 2300 F is reached. Key ingredient is chlorendic acid, which becomes a permanent part of the chemical structure of the resin and does not adversely affect other properties of the coating. Mineral spirits can be used as thinner and solvent. When dried vertically, wet film, 1.5 mil thick, exhibits less than 1/64-in. sag. Paint may be applied with hot spray equipment. Chlorendic acid is 45¢ per lb in carload quantities, FOB Niagara Falls. **Eastern Chemical Div, Hooker Chemical Corp, Box 344, Niagara Falls, NY.**

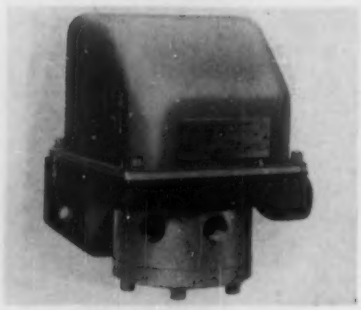
**Circle 302 on Reader Service Card**

## Self-aligning electrical connectors . . .

utilize two-ball and split-sleeve design. Ball end of each contact pin mates with split-sleeve socket that is loosely retained with one of the balls, forming a receptacle unit. Split-sleeve is compressed with two garter springs, providing expansion or contraction of sleeve to allow entrance or withdrawal of mating ball pin regardless of alignment of pin or connector. Connector may have any number of contacts of various capacities and in whatever configuration is required for the particular purpose. Because pins can be inserted at any angle, hinge-type connectors can be used. Contact pins are available in 15-, 30-, 75-, 150-, and 300-amp capacities. Any combination of pin sizes can be used in a single connector. For sequence switching, long and short pins can be used in either standard plugs or dead-front units. Pin length controls sequence. In tests, connector is reported to have withstood being

dropped 5½ ft to pavement for 2000 times without major damage; vibration to 85 g; operation from —65 to 160 F at 0 to 100% humidity, at pressures from 0 to 30 psia. Also withstands air, water, salt water, jet fuel, exhaust gases, oil and hydraulic fluid. Plug and receptacle average about $350 in 7½-in. size. Delivery, about 2 wk. **Cole Electric Co, 8439 Steller Dr, Culver City, Calif.**

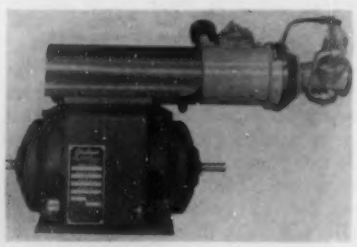
**Circle 303 on Reader Service Card**



## Differential pressure transmitters . . .

originally designed for detecting liquid levels in shipboard nuclear secondary plant instrumentation systems, are applicable for general flow and differential-pressure measurement and transmission. Units measure difference in pressures between two points in fluid system and transmit information as electrical output, which can be used directly for indication and/or control with available industrial instruments. Standard model measures differential pressure from 0 to 80 in. water directly. Span can be adjusted to provide full output signal over upper 30% of this range. Electrical output over range of differential pressures varies from 0 to 1 milliamp dc into 750-ohm load. Self-contained regulator and demodulator maintain linearity despite variations in excitation voltage. About $1000. Delivery, 4-5 mo. **Consolidated Controls Corp, Bethel, Conn.**

**Circle 304 on Reader Service Card**



## Infinite-range speed control . . .

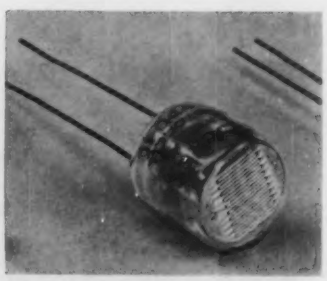
is provided by air signals, varying from 3 to 15 psi, producing linear speed variation from any desired max speed to zero. Speed may be set by manual air valve or automatically by signal generated by variety of pneumatic transducers. Control incorporates pinion driven by rack mounted on piston of pneumatic actuator. Pinion shaft carries steel cam, cut so that equal changes in air-pressure signal will produce equal changes in speed. Because transmission is form of differential, overload protection is afforded, since there is small change in speed of traction members in event of a jam. Delivery, 3-4 wk. **Graham Transmissions Inc, Menomonee Falls, Wis.**

**Circle 305 on Reader Service Card**

## Copper-nickel-silicon alloy . . .

is said to offer high tensile strength (90,000 psi min), high yield strength (70,000 psi min at 0.50% extension under load), high electrical conductivity (30-42% IACS as heat treated), high corrosion resistance and excellent cold-forming characteristics before hardening heat treatment. Intended for applications where its combination of physical, mechanical and fabrication properties is needed, such as in electrical equipment. Compared with free-cutting brass rod at 100, its machinability rating is about 40. Alloy has density of about 0.322 lb per cu in. and its coefficient of thermal expansion per degree F from 68 to 572 F is about 0.000,009,8. Made in round rod, with or without final precipitation-hardening heat treatment, in straight lengths including 3/16 to 1 in. dia and coils including 3/ to ⅜ in. dia. Delivery, about 2-3 wk. **American Brass Co, Waterbury, Conn.**

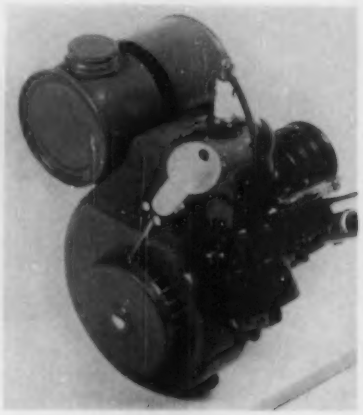
**Circle 306 on Reader Service Card**



## Low-resistance photoconductive cells . . .

hermetically sealed in glass are rated at 60 v max with resistance as low as 40 ohm at 100 ft-c. Standard line consists of seven types, five of cadmium selenide variety and two of cadmium sulphide. Provide choice of resistance, speed and spectral response. Units offer power dissipation range to ½ w continuous and high ratios of light to dark current even at low light levels. Available in three-package configurations of 400, 500 and 600 series, ranging from 0.25 to 0.5 in. dia and from 0.5 to 1 in. long. Priced from $1.15 to $4, depending upon quantity. **Clairex Corp, 19 W 26th St, New York 10.**

**Circle 307 on Reader Service Card**



## Industrial, 2-cycle gas engines

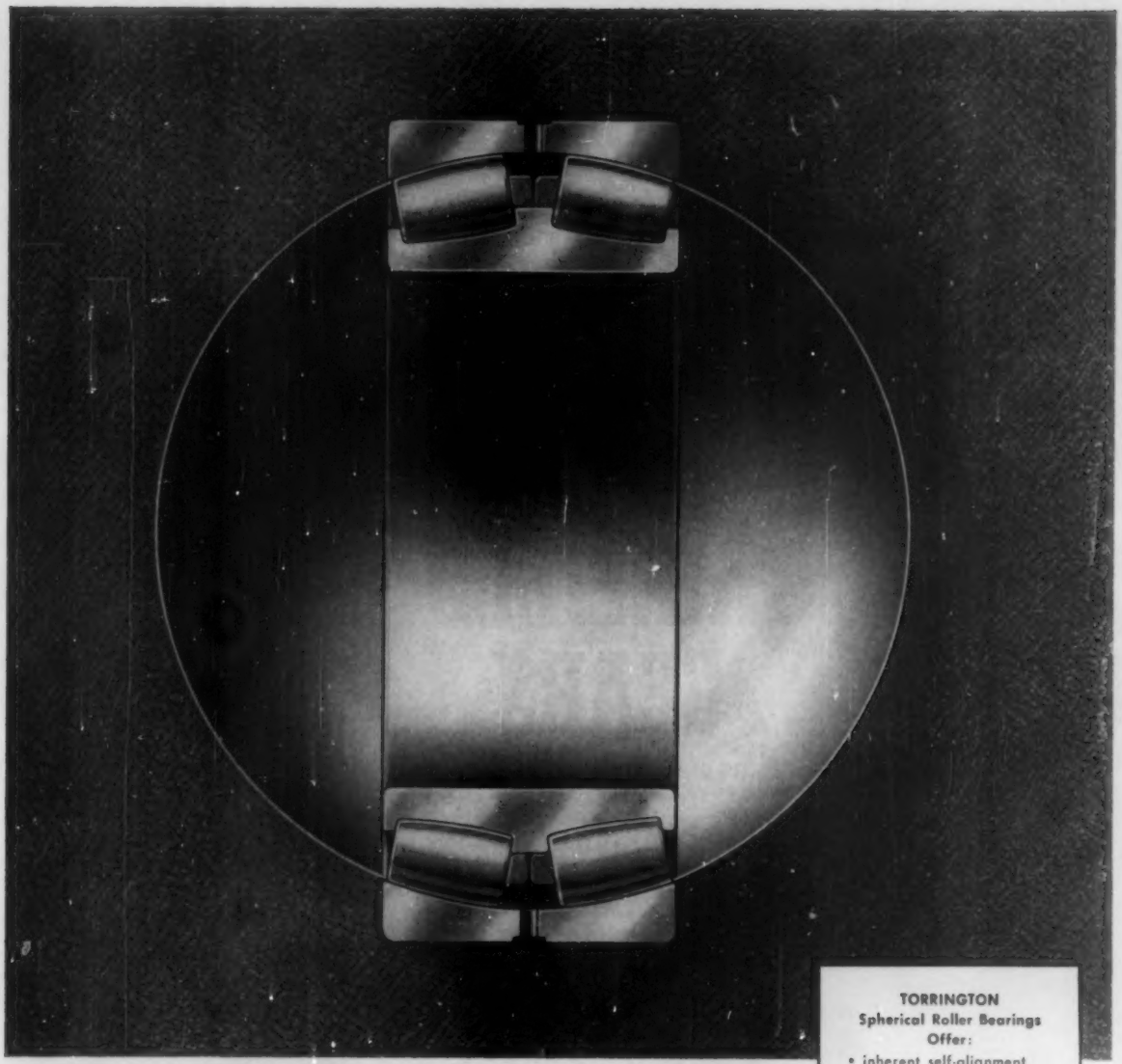
are offered in power ranges from ½ to 1 hp, the latter being intermittent, depending on compression ratio and use. Engines are said to run equally well in any attitude and are immune to ordinary acceleration force. Supplied with round fuel tank on bracket on the side or an upright engine-mounting base tank. Sensitive throttle governor is said to maintain very near constant load and no-load rpm. Carburetor is diaphragm-type, with throttle arm arranged to overcome governor through Bowden control for idling purposes. Choke has choke, half and open positions. Fuel metering is through single jet. Governor is factory-set at 6300 rpm. Cylinder displacement is 1.26 cu in. Engine measures 5¾ in. high and weighs 3¼ lb without tank, 3¾ lb with tank. Available in integral gear models with shaft speeds of 3200, 1750 and 900 rpm, with ½-in. shaft extensions. Particularly suited for use with hand-held tools and appliances. **Ohlsson & Rice Inc, 3340 Emery St, Los Angeles.**

**Circle 308 on Reader Service Card**

## Insulating material . . .

incorporates synthetic resins to give it two to four times moisture resistance of conventional vulcanized fiber. Also maintains electrical properties and mechanical strength of vulcanized fiber. UL-approved for sole support of current-carrying parts up to 302 F. Can be drawn or formed into permanent shapes. Available in 0.004-in. to ⅛-in-thick sheets; 48 in. wide and 72 in. long. Suitable as circuit-breaker barriers, wiring devices, electrical-fixture in-

continued on page 88



## IN TORRINGTON SPHERICALS . . . NO COMPROMISE WITH QUALITY

The spherical design concept of Torrington Spherical Roller Bearings means superior performance and outstanding service life under the toughest operating conditions. It means inherent self-alignment, high radial and thrust load capacity, low friction. It allows compensation *within* the bearing for both dynamic and static misalignment.

Roller guidance is positive and accurate... is assured by grinding roller ends and center guide flange surfaces to a common spherical radius. Results are truer rolling motion, minimum friction and higher degree of geometric stability. Bearing operation is cooler, quieter, smoother.

If you're looking for outstanding bearing performance and bearing *value*, you should specify Torrington Spherical Roller Bearings. Backed by Torrington's uncompromising experience in engineering and manufacturing every basic type of anti-friction bearing, their quality is unmatched.

**TORRINGTON**
**Spherical Roller Bearings**
**Offer:**

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life

***send for new Torrington Spherical Roller Bearing Catalog #258***

*progress through precision* **TORRINGTON BEARINGS**

**THE TORRINGTON COMPANY** South Bend 21, Indiana • Torrington, Conn.

MACHINES ON THE MOVE...

—equipped with

FAIRFIELD GEARS

GEARS to match the speed, size, and power of modern machines are a Fairfield specialty. This is possible because Fairfield is a leader in utilizing the most advanced methods, machines, and techniques for producing better gears. By specializing exclusively in "Fine Gears Made to Order", Fairfield has become one of America's largest independent producers of these parts.

If you use gears in the product you make, we believe it will pay you, as it has others, to become acquainted with FAIRFIELD—the place where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY! Fairfield's production facilities are unexcelled. *Call or Write.*

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A "PLUS VALUE" IN ANY PRODUCT

*Gears and Differentials* For FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS



sulation, instruments and control panels and magnetic coil heads. National Vulcanized Fibre Co, 1060 Beech St, Wilmington 99, Del.

**Circle 309 on Reader Service Card**

**4-figure electric counters . . .**

are available for base, top or panel mounting with panel plate. Reported to operate at speeds up to 600 counts per min. Standard models operate on 115 v ac. Operation is based upon an escapement drive mechanism. Driving parts are nylon with special hardened stainless steel drive shaft. Suitable for all types of business machinery, vending machines and packaging machinery. Priced at $14. Durant Mfg Co, 1938 N Buffum St, Milwaukee 1.

**Circle 310 on Reader Service Card**

**Extruded acrylic lenses . . .**

in small to medium sizes for noncritical magnification are now available. Extruded lenses are said to be more economical than an equivalent molded one (tooling, $100 to $300) and can be supplied in any length without additional tooling. Anchor Plastics Co, 36-36 36th St, Long Island City 6, NY.

**Circle 311 on Reader Service Card**

**Stock circuit cards . . .**

that can be prefabricated and adapted to different circuit requirements contain universal etched pattern, which can be modi-

continued on page 91

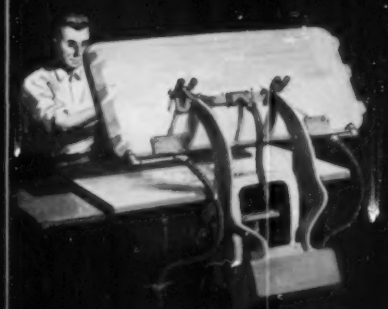
DUPONT

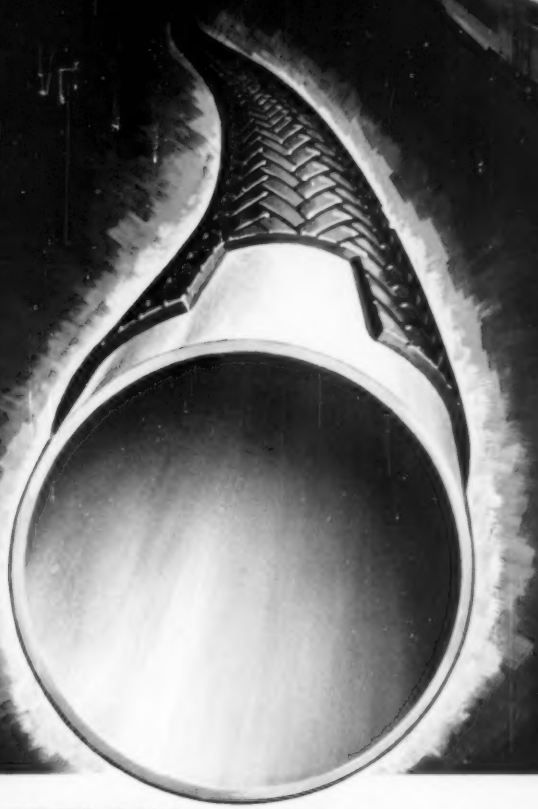
ENGINEERING FACTS ABOUT

# TEFLON®

FLUOROCARBON RESINS

No. M-9
in a series
MECHANICAL
DESIGN
Hose Lined
with TEFLON®





## Hose lined with TEFLON® provides economical solution to the most difficult fluid-handling problems

In any fluid-handling service involving such problems as temperature extremes . . . threat of corrosion . . . continuous flexing, torque or vibration . . . high pressures . . . adhesion of sticky substances, the use of hose lined with TEFLON TFE fluorocarbon resins provides a uniquely effective solution. Such hose can give longer life and better performance, cut replacement and maintenance expenses, prevent costly downtime, and in fact do jobs for which conventional hose could not have been considered.

TEFLON resins are inert to virtually every chemical and solvent. The TFE resins are rated for continuous use up to 500° F.

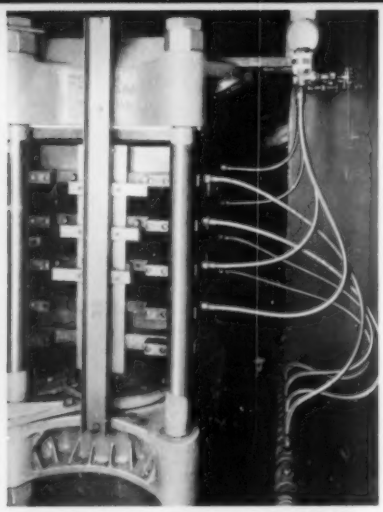
Hose lined with TEFLON also offers long flex life, easy cleanability and unique anti-stick properties. With reinforcing, service pressures up to 6,000 psi are being achieved.

A wide selection of industrial hose constructions with liners of TEFLON TFE resins is now available to meet your needs. In addition to the wire braided reinforcement and a variety of industrial couplings, there are elastomer coverings, fiber braids and convoluted liners of TEFLON for extra flexibility.

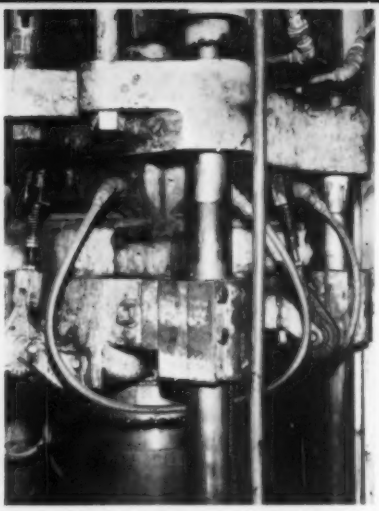
On the following page you will find some examples of the cost-cutting advantages made possible by hose lined with TEFLON TFE fluorocarbon resins.

OVER

# Hose lined with TEFLON® offers high heat resistance . . . long flex life . . . unsurpassed durability

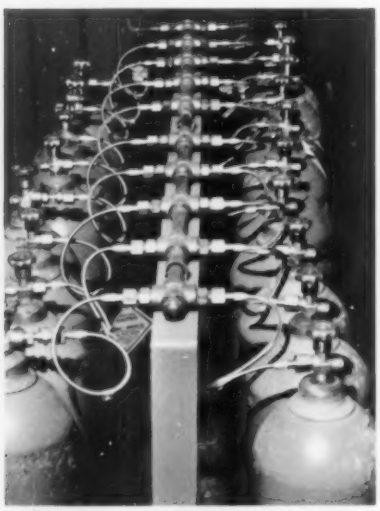


**HEAT RESISTANCE:** Hose is in alternate 350°F. steam and cold water service on this plastics platen press. Prior to the use of hose lined with TEFLON, scale formation plugged the hose in a matter of months. After 5 years, seven hoses lined with a TEFLON TFE resin were still unharmed and unplugged.



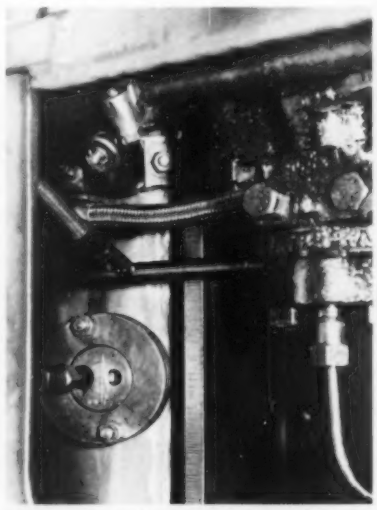
**HEAT RESISTANCE:** Steam press used in the manufacture of battery casings relies on hose lined with TEFLON to withstand tough operating conditions. Eight hoses are used in each of the steam presses, which have operated more than three years without a hose failure. Hoses formerly used were replaced every few months.

**LONG FLEX LIFE:** Cleaners and garment manufacturers are now using hose lined with TEFLON fluorocarbon resins carrying steam to their presses. Above is one of 100 units at a location so equipped 16 months ago, and there have been no failures. Previously, hose life on some units was as low as two weeks.



**LONG FLEX LIFE:** At this plant, rubber hoses or metal pigtails lasted 3 months at best, loading helium, nitrous oxide, and carbon dioxide into cylinders. Hoses lined with TEFLON show no deterioration after 16 months. Reduced stiffening and frosting at the 0°F. loading temperature improved the weighing accuracy.

**DURABILITY:** Hose lined with TEFLON TFE resin helped adapt this standard roller coater machine to corrosive high-temperature service. To suit customers' needs, the hose had to handle heat transfer oil at up to 400°F. Hose lined with a TEFLON TFE resin provided the necessary resistance to heat and solvents.



**DURABILITY:** Fuel header of a locomotive uses 12 feet of hose lined with TEFLON to carry fuel to the injector pumps. These fuel lines have demonstrated exceptional durability in service. They have been installed on 5 locomotives, and will be put on all locomotives as they come in to be overhauled.

***FOR MORE INFORMATION*** about reliable hose installations, and the design properties of Du Pont TEFLON resins that make possible this superior hose performance, consult your hose supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-36711, Room 2526, Nemours Building, Wilmington 98, Delaware.
In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

**TEFLON®**
**FLUOROCARBON RESINS**

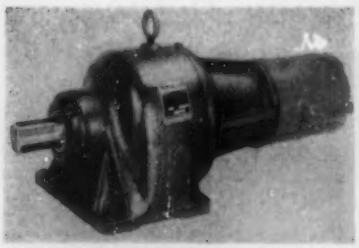
*TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.*

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

fied by interconnections to form any desired circuit function. Particularly adaptable to short-run and prototype production, where lead time between design and actual start of production is usually excessive. Production is divided into preassembly stage, which takes place before logical design of computer has been firmed, and working out of interconnections of individual modules to provide proper circuits. Because etched circuitry is carried through from base plug of each card to top of card where duplicate connector is provided, card can be connected to test instrument while it is plugged into computer or equipment. **Librascope Div, General Precision Inc, Glendale, Calif.**

**Circle 312 on Reader Service Card**



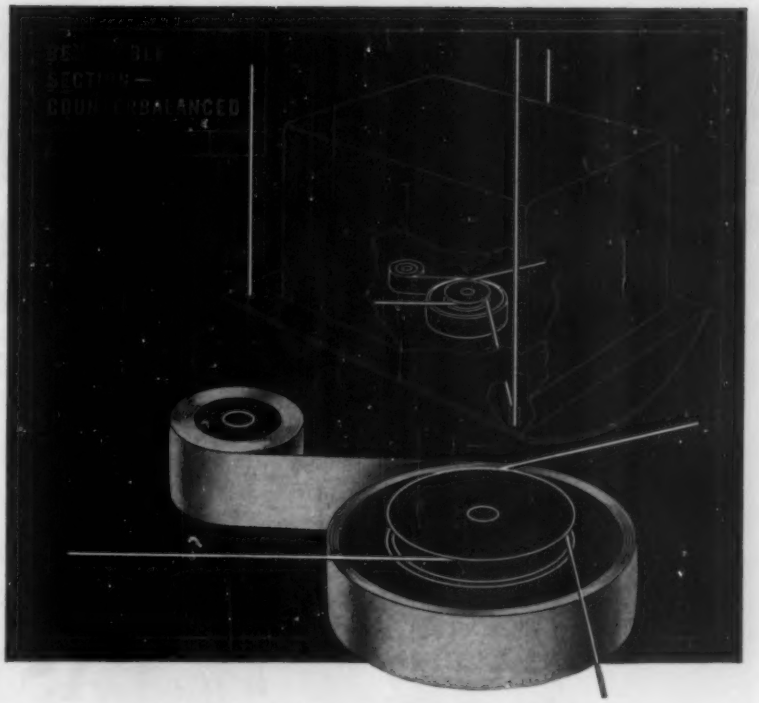
**Differential speed reducers . . .** in seven horizontal motorized models, with ratios from 1.1:1 to 50,000:1, 0.12 to 81.51 hp, offer max output torque range of 50 to 113,000 in.-lb. Unified helical-gear planetary element automatically equalizes load distribution through planetary gears by means of floating principle. Unified planetary element rides on cushion of oil between planetary and internal gear teeth. Reducers fit any standard C-flange motor and over-all dimensions of individual models never vary, regardless of reduction ratio. Units require no bed plate. **Winsmith Inc, 23 Eaton St, Springville, Erie County, NY.**

**Circle 313 on Reader Service Card**

**Ultrahigh-strength steel . . .** originally developed for missile motor cases is now available for general industrial use. The cobalt-modified, low-alloy constructional steel is reported to have two to three times the strength of normal construction steels and yet can be readily fabricated by rolling, forming, deep drawing, welding and machining. Sustains multi-axial loading and is said to be highly insensitive to weaknesses created by notches, cracks and head treatment. Available in all standard mill forms. In tests, alloy has withstood 280,000 psi burst pressure. **Scaife Co, 126 Ann St, Oakmont, Penna.**

**Circle 314 on Reader Service Card**

continued on page 94



*Counterbalance Without Mass*

**USING A NEG'ATOR* SPRING**

Wind a NEG'ATOR constant-tension spring around a drum, then reverse-bend and wind the free end around a larger drum and you have a powerful, constant-torque motor.

Used as an internal counterbalance, for example, a NEG'ATOR motor offers unusual advantages over any other type of mechanism. Because it weighs only a small fraction of the force it exerts, this mechanical motor offers spectacular savings in over-all weight and permits greatly simplified designs. Complete freedom is obtained in mounting and location. Working space becomes available. Massive external dead weights, tracks, guides, tubes, and complex linkages are eliminated.

The simplified illustration above resembles an actual application where a single NEG'ATOR motor with three cables on an output drum reel provides exactly balanced suspension of a 36 lb. aircraft gyro amplifier. Only a NEG'ATOR could perform this operation because of critical space and weight limitations. The gyro amplifier can be lowered as far as necessary below the fuselage for routine servicing. The entire counterbalancing unit, including NEG'ATOR, storage and output bushings, cable drum and fittings, occupies a space of only 8¼ in. x 5 in. x 2½ in.

This is just one of many such cases where NEG'ATORS in extension spring or motor form have provided *internal* counterbalancing for floating or assisting. Other such applications and details on NEG'ATOR springs are described in Bulletin 310N. Send for your copy.

*NEG'ATORS *is a registered trade mark of Hunter Spring Company.*

**HUNTER SPRING COMPANY**

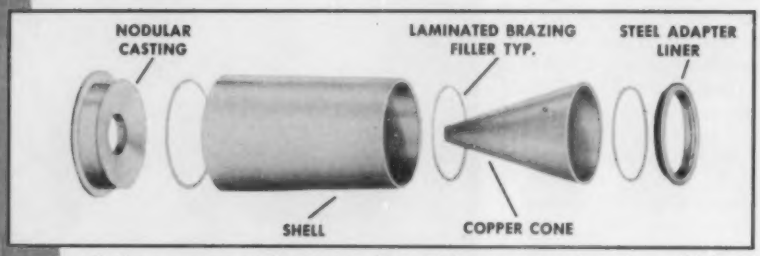
*A Division of American Machine and Metals, Inc.*

*5 Spring Avenue, Lansdale, Pennsylvania*

SPRINGS • STAMPINGS • QUALITY CONTROL EQUIPMENT



CIRCLE 91 ON READER SERVICE CARD




The four components of the nose assembly—nodular iron casting; low-carbon welded steel canister which measures 34" long, 15½" diameter at one end and 17¾" at the other; spun copper cone and low-carbon steel ring. The thinner rings are Easy-Flo 45 wire braided for precise alloy position and control.

# *Martin Develops New Induction Heating Methods to Braze Lacrosse Missile Assembly With* EASY-FLO 45

One of the largest assemblies yet brazed by induction-heating techniques is a section of the Lacrosse missile being manufactured at The Martin Company's Baltimore Division. During development, one problem was posed by the variety of metals used. First it was necessary to braze a low-carbon welded steel canister and nodular iron casting. Then, to complete the assembly, a spun copper cone and low-carbon steel ring were joined to the canister. An induction coil was designed by Martin to accomplish this critical operation. Temperatures had to be restricted between 1300 and 1350°F to prevent a transformation change to the crystalline structure of the nodular iron. Martin's Materials Engineering Laboratory made careful examinations of this assembly and found that Handy & Harman Easy-Flo 45 Silver Brazing Alloy and B-1 Flux make possible the strong, uniform joints necessary to meet the stringent requirements the Company has set. Its low-working temperature, high strength, fast penetration and flow characteristics are only a few of the features which make this brazing alloy ideal.

More and more aircraft and missile components are being made with the aid of Handy & Harman silver brazing alloys and flux. The products described here are just two of the many available to help solve your problems...make your job easier and quicker. For a more complete picture of silver brazing and the advantages it offers you, write for your free copy of Bulletin 20.

*Your No. 1 Source of Supply and Authority on Brazing Alloys*

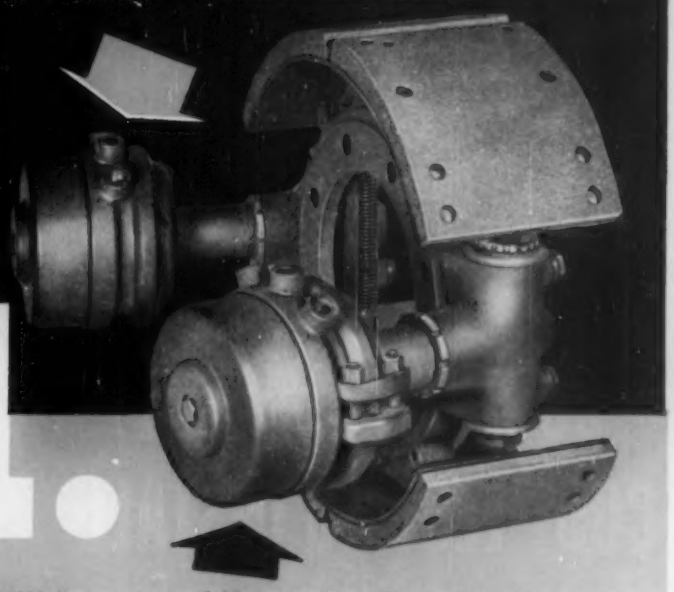
**HANDY & HARMAN**

General Offices: 82 Fulton Street, New York 38, N.Y.

# NEW STOPMASTER BRAKE

## OFFERS THESE 3 BIG EXTRAS!

ANOTHER ROCKWELL-STANDARD FIRST!



**1.**

**Proven the most advanced brake design in 30 years . . .**

Outstanding improvements, such as a new balanced shoe actuation principle and 15" diameter, have made the Stopmaster Brake the industry's most efficient and dependable brake. Now Rockwell-Standard also offers you these three important extras in the Stopmaster:

**"Fail-Safe" Units . . .** now available for air actuated Stopmaster Brakes.

- Prevents runaway vehicles due to loss of air, when in operation or parked.
- Positive mechanical operation . . . can be installed to operate from dash control valve or automatically, or both ways if desired.
- Lightweight and compact . . . no installation problems, no cables or special brackets required.
- Provides mechanical parking brake . . . eliminates need for prop-shaft brake.
- Brakes easily released . . . without air pressure.

**2** **Automatic Brake Adjustment . . .** available on all Stopmaster Brake sizes for trucks, trailers, and off-highway vehicles.

- Eliminates periodic manual adjustment.
- Cuts expensive maintenance costs.
- Brake maintains proper adjustment during entire lining life.
- Safer operation at all times.

**3** **Lubrication Eliminated.** All actuating parts are sealed in lubricant. Standard on all models.

- Prevents oil-soaked linings due to over lubricating.
- Moving parts last longer.
- Reduces friction.
- Completely sealed unit reduces effect of elements.

*Another Product of...* **ROCKWELL-STANDARD CORPORATION**

ROCKWELL R STANDARD

Brake Division, Ashtabula, Ohio



CIRCLE 93 ON READER SERVICE CARD 93

LONG LIFE, *THOMSON* "Snap-In"

# NYLINERS®

–BEARINGS of smooth, tough DuPont NYLON

Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

## COST LESS to BUY
## COST LESS to INSTALL
## & ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

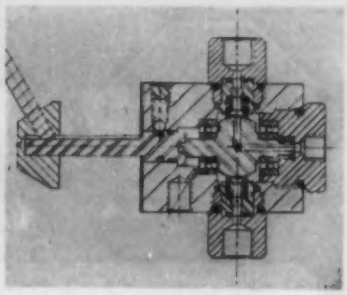
Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

**THOMSON INDUSTRIES, Inc.**

**DEPT. 11, MANHASSET, NEW YORK**

Also— –Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting



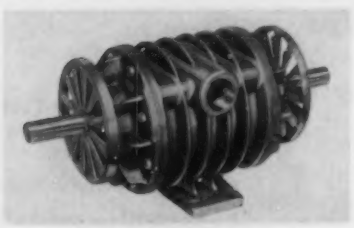


**3 low-voltage dc motors . . .** available for general use may be obtained with or without radio suppression. Winding designs offered include shunt, compound or series types. Typical ratings for R & M frame size 4636 are ⅛ hp, 3500 rpm, 12 or 24 v dc; ¼ hp, 2100 rpm, 12 or 24 v dc; and ½ hp, 3600 rpm, 24 v dc. Each motor has 5½-in. frame dia and weighs about 14.5 lb. Motors are built in totally enclosed nonventilated or totally enclosed fan-cooled cast aluminum housing and are equipped with ballbearings. **Universal Motor Div, Robbins & Myers Inc, Springfield, Ohio.**

**Circle 315 on Reader Service Card**

**Multiple selector valve . . .** is six-position, manually operated unit for hydraulic circuits. Spherical rotor design permits selection of flow from any of six sources or directs one flow to one of six circuits. Built for 0 to 6000 psi operating pressure and 10,000 psi proof pressure. Valve has rated flow capacity of 0.5 gpm. Standard valves are available with ⅛ in. NPTF and ¼ in. SAE ports. **Sarasota Precision Products Inc, 5757 McIntosh Rd, Sarasota, Fla.**

**Circle 316 on Reader Service Card**



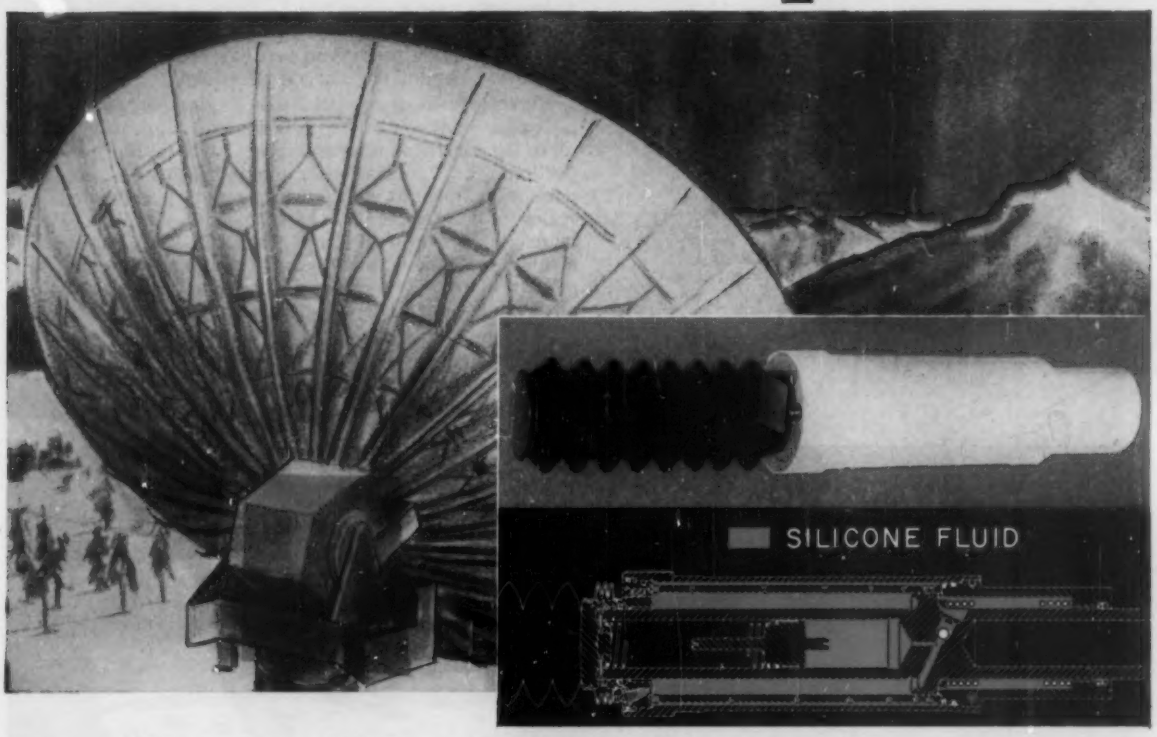
**Dry-air pump . . .** is said to increase airflow by 20%. Available in three models, with and without shaft seals in iron construction. It is a rotary positive-displacement pump, which delivers dry air for either pressure or vacuum applications. Four carbon-alloy pump vanes in rotor are self-lubricating and are seated by centrifugal force delivering continuous airflow. Reported to be manufac-

continued on page 98

**←CIRCLE 94 ON READER SERVICE CARD**

**SILICONE NEWS from Dow Corning**

# Silicones Soak Up Shock




## Dow Corning Damping Fluids Unaffected by Cold, Heat, Time

"Steady-state" fluids — that's what some engineers call these exceptionally stable damping media. And steady they are. Their useful range extends from as low as —100 F on the cold side to over 400 F on the hot side! Within these extremes, viscosity varies but little. They're resistant to oxidation and to breakdown under shear; won't sludge; won't corrode metals. Because of such properties, silicone fluids are highly effective media for damping, springing and torque converting.

Illustrated above is one example. It's a Radar Antenna Buffer, designed and built by Houdaille Industries, Buffalo, N. Y. Radar equipped with this unit, "Has silicone; won't over-travel." For that's where the buffering comes in. When the antenna swings to its travel limit, something must give, or the structure may be shock-damaged. What "gives" is the Buffer, and the working medium is Dow Corning silicone fluid. Because the damping fluid's viscosity is unaltered by temperature changes, performance of the Buffer varies less than 1% per 100 Fahrenheit degrees. That's important, because installations of ballistic missile early warning radar, which use the Buffer, may vary from tropic to Arctic.

This is but one of many designs where silicone fluids have aided the product engineer. Others include auto fan drives, aircraft oleo struts, missile accelerometers, and truck scales. If in your design you require a high performance damping or coupling fluid, investigate Dow Corning Silicones . . . the fluids with "steady-state" viscosity. Write to Dept. 7207 for more detailed information.

**TYPICAL PROPERTIES OF DOW CORNING 200 FLUID***

| Centistokes at 25 C | Pour Point, °F | Visc/temp.[1] Coefficient | Coeff. of Expansion cc/cc/°C |
|---|---|---|---|
| 10 | —85 | 0.57 | 0.00108 |
| 50 | —67 | 0.59 | 0.00104 |
| 100 | —67 | 0.60 | 0.00096 |
| 500 | —58 | 0.62 | 0.00096 |
| 1,000 | —58 | 0.62 | 0.00096 |
| 12,500 | —51 | 0.58 | 0.00096 |

*Available in a range of viscosities to over a million centistokes.

[1] $1 - \frac{\text{Viscosity at 210 F}}{\text{Viscosity at 100 F}}$

Your nearest Dow Corning office is the number one source for information and technical service on silicones.

first in silicones

**Dow Corning CORPORATION**
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.



CIRCLE 95 ON READER SERVICE CARD 95

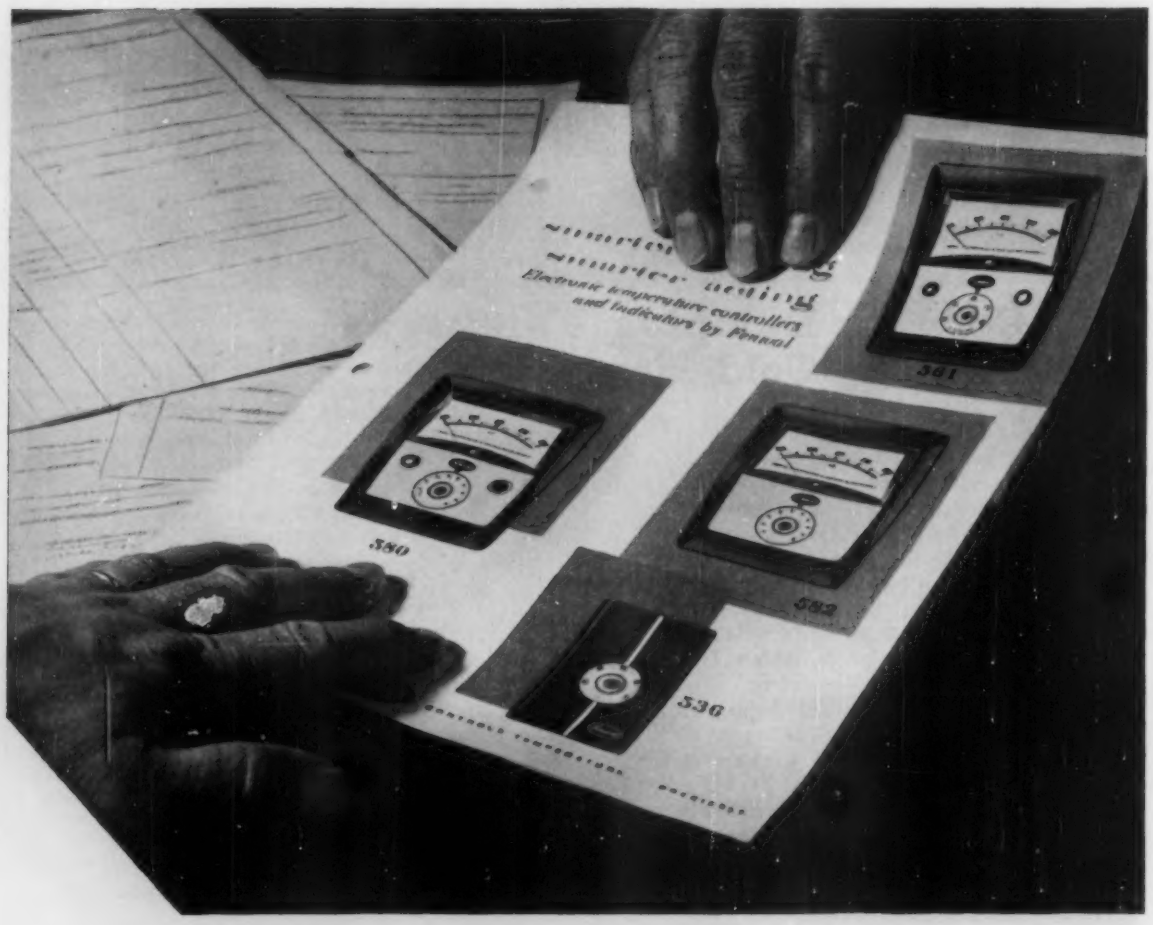
# *"Wait!*
# I need it too!"

*Everyone* concerned with temperature control will want to read this new Fenwal Bulletin, "Smarter Looking — Smarter Acting Electronic Temperature Controllers and Indicators."

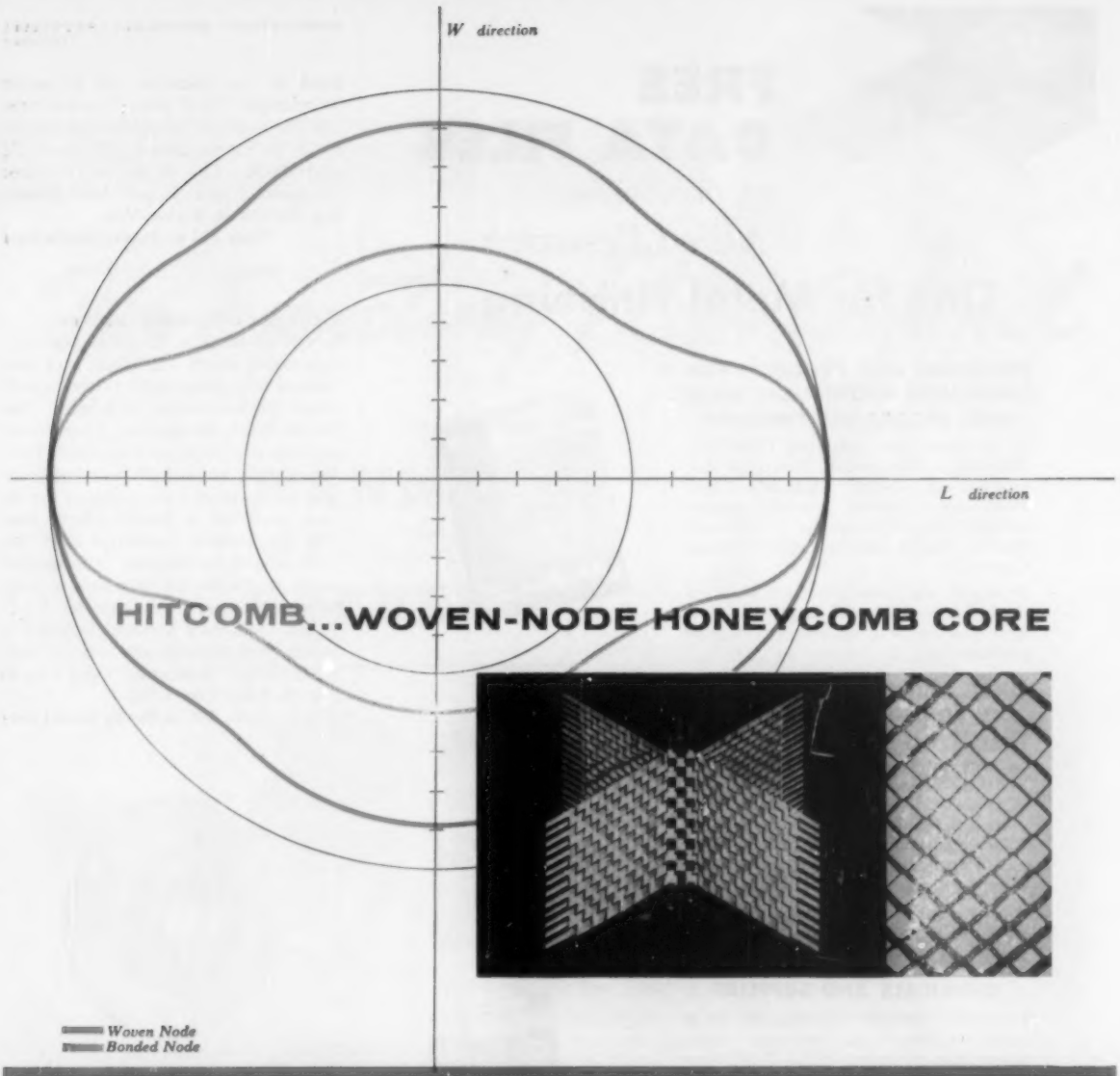
These modern transistorized instruments with thermistor sensors can be *more precisely matched* to requirements over a range from −50 to +600°F. Their many interchangeable, optional features let you order *exactly* what you need. And you can *combine* instruments . . . "build" to your specifications.

Here are just a few possibilities: single-point control . . . single-point control and indication . . . indication of up to ten controlled temperatures . . . ON-OFF or proportioning . . . indicating or non-indicating . . . set-point adjustment at instrument or remote . . . expanded scales for fine temperature adjustment . . . and many more. Ratings up to 10 amp/110 VAC. Each instrument is professionally styled to perfectly complement modern industrial machines or interiors. And, best of all, Fenwal design keeps costs *reasonable*.

Get your copy of "Smarter Looking — Smarter Acting." Then get the *benefits* of this versatile new instrument family. Write FENWAL INCORPORATED, 28 Pleasant Street, Ashland, Mass.




*Another example of how* Fenwal CONTROLS TEMPERATURE . . . PRECISELY




HITCOMB...WOVEN-NODE HONEYCOMB CORE



a new high in high temperature structural core material

HITCOMB is a new concept in core for high-temperature sandwich panel applications. HITCOMB, made by a unique three-dimensional weaving process, demonstrates isotropic physical properties at elevated temperatures, since it has square cells and does not depend on an adhesive bonded node line.

This material is already showing superiority through structural applications in space craft capsules, as well as in structural heat shields. HITCOMB fiber glass core exceeds all physical property requirements of specification MIL-C-8073A. It is available in fiber glass and REFRASIL® for use where ultra-high temperatures may be encountered. Both REFRASIL and fiber glass forms are currently available with many of the popular resin systems such as phenolics, phenyl-silane, silicones, polyesters and epoxies.

*Write for Technical Products Bulletin PSS-2*

**H. I. THOMPSON** FIBER GLASS CO. 733 Cordova Street • Los Angeles 7, Calif. • REpublic 3-9161

WRITE OR CALL YOUR NEAREST HITCO FIELD ENGINEER: EASTERN: Tom Kimberly, 18 Crescent Circle, Cheshire, Conn., BR 2-6504; Fred W. Mahlenbrock, 3659 Loch Raven Rd., Baltimore 12, Md., VA 5-3135 • MIDWEST: Bernie Weddle, 3719 W. 79th St., Indianapolis 22, Ind., WA 6-8615 • SOUTHWEST: Marshall Morris, 2850A W. Berry, Rm. 7, Fort Worth, Tex., WA 4-8479 • NORTHWEST: J. L. Larson, 5757 Oakdown Pl., Seattle, Wash., PA 6-4211 • SAN DIEGO: John Veil, 9048 Haverstar Way, JU 2-6393 • CANADIAN PLANT: THE H. I. THOMPSON CO. of CANADA LTD., 60 Johnston St., Guelph, Ont., TA 7-6671

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Price and delivery information on a wide variety of plating room necessities, including ROLL-TOP Zinc anodes, FLAT-TOP copper anodes, ELECTROCOP Flat Copper anodes, Cadmium and Tin Anodes, Acid Replacements, Buffs, Chemicals, Cleaners and Maintenance Materials.

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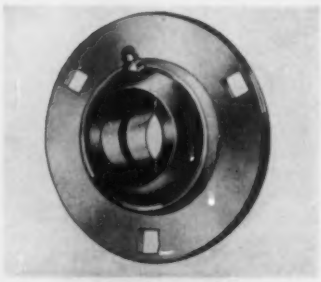
tured to close tolerances and to permit interchangeability of parts. Develops pressures up to 15 psi continuous and vacuum to 20 in. Hg continuous and 24 in. Hg intermittent. Dry air can be two-staged for pressures up to 35 psi. **M-D Blowers Inc, 100 4th St, Racine, Wis.**

**Circle 317 on Reader Service Card**

**Cylinder-operated valves . . .** in sizes up to 1¼ in. ID are available in a space-saving design. Cylinders have been changed from pivot mount to nose mount, which eliminates bulky pivot beam. Can be installed in any position for automatic sequence or multiple-valve operation. Pneumatically or hydraulically operated cylinders can be adjusted to operate at any desired speed and to control process flows with straight-through, disk-type valve. Remote control by electrical or mechanical means is possible for hazardous or hard-to-reach locations. Available for ⅛-, ¼-, 1- and 1¼-in. valve sizes and furnished in bronze, steel, stainless steel and iron-body construction. **Everlasting Valve Co, 49 Fisk St, Jersey City 5, NJ.**

**Circle 318 on Reader Service Card**



**Center-flange bearings . . .** for heavy-duty service are self-aligning. Three basic sizes carry either pressed-steel or cast-iron sleeve-type bearing-ball units. All standard shaft sizes from ½ to 1¾ in. are available, with choice of oil or grease lubrication. Mountings are made from 13-ga steel. Interchangeable with ballbearing flange units. Bolt holes can be varied in size, shape, number or location. **Triangle Mfg Co, Oshkosh, Wis.**

**Circle 319 on Reader Service Card**

**Fiberglass machine mount . . .** isolates vibration and eliminates need to lag-down machinery. Mount is said not to creep, permitting use of mobile rather than permanently installed machinery. Mounts are used where built-in level control is not required. Previous model is equipped with built-in level control. Both


continued on page 102

. . . MICROMETER SETTING

# *For Exacting Flow Control*

## HANNA *Flo-Set* VALVES

Hydraulic pressure to 1000 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

Air, Oil, water operation to 250 psi
Sizes ¼", ⅜", ½", ¾"
Temperatures to 250°F

**OTHER HANNA VALVES**
***Include solenoid, pilot, hand and foot operated types***

**FOR AIR • OIL • WATER • OTHER FLUIDS**

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

***WRITE FOR LITERATURE AND COMPLETE DETAILS,***
*or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.*

## Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1763 Elston Avenue • Chicago 22, Illinois



CIRCLE 99 ON READER SERVICE CARD 99

(Advertisement)

FIRST in strain measurement

SR-4 BALDWIN BLH LIMA-HAMILTON

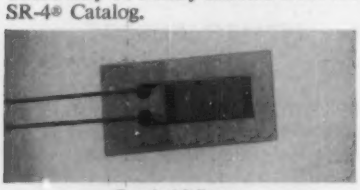
# STRAIN MEASUREMENT

DATA SHEET No. 2

## HOW TO MATCH THE STRAIN GAGE TO THE JOB

If your business is mechanical design, development or testing, chances are good that you have used, or will some day use, SR-4® Bonded-Filament Strain Gages. Unique in their simplicity, versatility and accuracy, they are the natural answer to a great many problems involving the behavior of materials, components and structures under load.

When the need arises, however, many engineers without specific background in strain-gage techniques find themselves on unfamiliar ground in attempting to select the best gage for the job from over 250 available types. Although it is important to the validity of the results that the gage used be properly suited to the application, selection is normally not a difficult matter and depends principally on known test conditions and on the nature of the data required. When the following criteria have been established, a suitable gage type for a specific application may be readily selected from the SR-4® Catalog.



Bonded foil gage

**1. Temperature**—The temperature at which the test is to be conducted is an important (frequently limiting) factor in determining suitable grid and base materials. At room and moderately high temperatures, both wire and foil gages are used. At temperatures above 350°F (and at very low temperatures), foil gages must be used. Some types are available with a backing material which may be stripped off during application, the grid alone being bonded to the test area. Such gages may be used up to 1400°F (for dynamic-type tests).

SELECTION OF GAGE MATERIALS BASED ON TEMPERATURE

| Maximum Temperature (°F) | Base Material | | Filament Material |
|---|---|---|---|
| 180 | Paper, Bakelite, Epoxy | | Any |
| 250 | Bakelite, Epoxy | | Any |
| 350 | Bakelite | | Any |
| 600 | None | Strippable backing | Constantan or Nichrome foil |
| 1000* | None | | Nichrome foil |
| 1400* (dynamic only) | None | | Nichrome foil |

*Limit imposed by available bonding adhesives

**2. Test duration**—For short-term tests (a few days) at temperatures below 150°F, paper-base gages are satisfactory and are usually more economical than other types. Extra-thin paper gages speed the curing of the bonding cement for fast application. For longer test periods (months or years), phenolic (Bakelite) or epoxy-base gages are usually used.

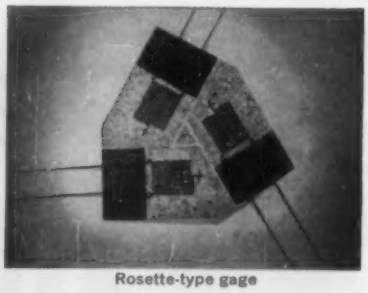
Dual-lead-type gages, with intermediate lead joints, provide good fatigue life. For better fatigue resistance and minimum hysteresis foil gages are advisable. They exhibit combined hysteresis and zero shift of less than 0.10% in strain reversals of up to ±1.5%, have generally higher fatigue resistance than equivalent wire gages.

**3. Strain type and magnitude**—For static strains, gages having grids of Constantan are usually used up to 600°F. For dynamic strains—particularly those of small magnitude—isoelastic gages are often recommended because of their relatively high strain sensitivity and improved fatigue resistance. Their high sensitivity to temperature change, however, limits usage to the measurement of vibratory strains unless appropriate precautions can be taken to cancel out or allow for this effect. When static strains of high magnitude (±2% to ±10%) are involved, a "post yield" gage is used.

**4. Test-area geometry**—Gage size depends primarily on the test space available. In general, the largest gage possible should be used. The probable strain gradient of the test area should also be considered, since the strain gage essentially averages the surface strain beneath its grid. When the test space is curved, foil gages are recommended, since they are flexible and will readily assume almost any continuous contour. When small wire gages are used, the new fine-pitch, flat-grid types are generally superior to "wrap-arounds".

**5. Strain direction**—Single-grid gages are used when the direction of the principal strain to be measured is known. If the strain field is biaxial and the directions are known, a 90°, 2-element rosette gage may be employed. When the strain field is unknown, a 3- or 4-element rosette may be used to determine the direction and magnitude of principal strains.

**6. Output requirements**—The required gage resistance and sensitivity are frequently dictated to some extent



Rosette-type gage

by the sensitivity of the measuring system to be used. Maximum gage output can be achieved by using a high-resistance gage with maximum bridge voltage.

**7. Temperature compensation requirements**—Strain gages are sensitive to changes in temperature as well as strain. This temperature effect on the measuring gage can often be canceled out by use of an unstressed "dummy" gage sensing identical temperatures and connected in the strain-gage circuit. In cases where a dummy gage cannot be used, some form of *self*-temperature-compensation is required. There are three general types of temperature-compensating strain gages available.

a. Self-temperature-compensating wire gages—individually compensated for specific materials and specific temperature ranges.

b. "Selected-melt" foil gages—with grids produced from a "melt" of strain-sensing material specifically selected for minimum temperature response over a specific temperature range.

c. Self-temperature-compensating foil gage—a recently developed grid design with an appropriate external circuit, which may be adjusted to provide minimum temperature response on any desired material over any temperature range.

### For Engineering Assistance

When tests involve unusual conditions (e.g., high frequencies, strong magnetic or radiation fields, etc.) or necessitate special gage configurations, unusually accurate data, etc., it is advisable to consult your local SR-4® Strain Gage Sales Engineering Representative. He can also supply you with information and specific recommendations on strain-gage instrumentation (static and dynamic), cements, waterproofing compounds, and other accessories.

To obtain a free copy of the latest B-L-H Strain Gage Catalog write Dept. 15-G.

BALDWIN · LIMA · HAMILTON
Electronics & Instrumentation Division
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SR-4® Strain Gages • Transducers • Force Measurement Systems

# use this page to develop an idea in 60 seconds

The Polaroid Land camera has had phenomenal sales success. It is expertly designed . . . the materials and workmanship are the best. Now, even the package is something special. The camera and accessories are cushioned in a seat of DYLITE® expandable polystyrene.

DYLITE's unique combination of properties—lightweight, shock resistance and easy moldability to any contour—make it the ideal choice for the variety of platforms and inserts used in Polaroid packages.

Additional properties of strength, water resistance and insulation have made DYLITE a leading choice of package designers in a wide variety of industries. Chances are it can make an excellent improvement in *your* package.

(60 seconds are up. Did you get an idea? Write to Koppers Company, Inc., Plastics Division, Pittsburgh 19, Pennsylvania.)

Offices in Principal Cities • In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

**KOPPERS PLASTICS**

*DYLENE® polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.*

How United States Testing Company helps

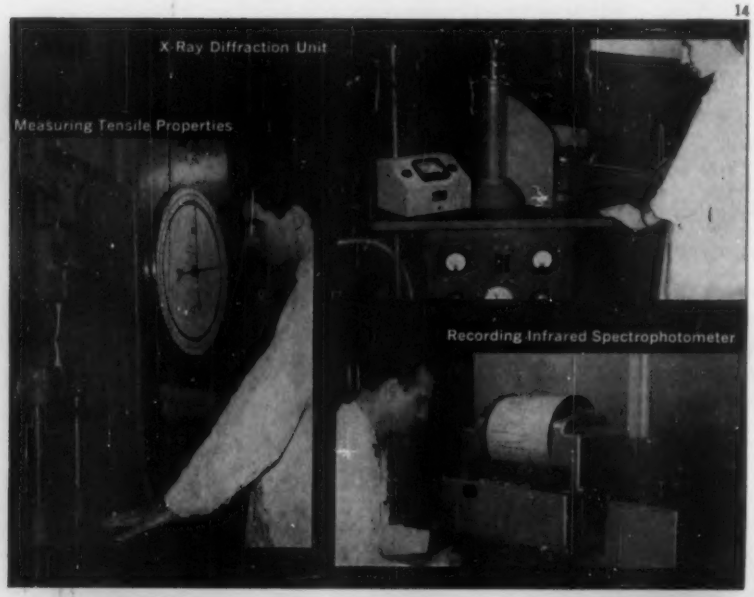
# STOP TROUBLE BEFORE IT STARTS

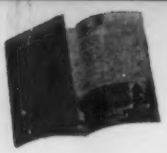
Spotting "bugs" in new products and eliminating them before marketing... that's how United States Testing Company saves clients thousands of dollars and priceless good will. Take the case of the new movie camera ready for the mass market... our test film went through without trouble, until a special spliced section jammed the sprockets and stripped a gear.

We examined the mechanism piece by piece and traced the fault to a structural defect in a key member. Our report to the client included end-use specifications for the defective part and a simple slip clutch design to prevent future gear failures.

Knowing how to induce failure in the laboratory, and prevent trouble in the field, calls for trained evaluation engineers... engineers who know sound corrective design, too. Why not apply this know-how to your new product. Write or phone for details. No obligation.

14



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models are available in three standard sizes to handle load ranges to 8000 lb per mount. Consolidated Kinetics Corp, 1065 Dublin Rd, Columbus 12, Ohio.

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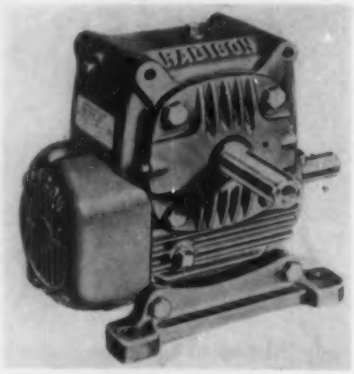

## Fan-cooled worm-gear reducer

has center distances as low as 1⅛ in., ranging to 8 in. Available in 12 sizes with input capacities from 0.01 to 68 hp and with output torque up to 46,000 in.-lb. Speed ratios are available from 5:1 to 70:1. Controlled transfer of heat by convection is obtained by a moving stream of air induced by max-diameter fan, which forces high-velocity air along horizontal channels formed by external ribbing in reducer housing. In addition to convection, heat is dissipated through radiation, assisted by vertical ribbing on unit. From stock. Said to be competitively priced. Box MJ, Foote Bros Gear and Machine Corp, 4545 S Western Blvd, Chicago 9.

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## Size 00 starter . . .

is magnetic, nonreversing unit said to be better suited than larger units for about 40% of all general-purpose applications up to 2 hp. For use with polyphase and single phase motors, starter is available as open type or in NEMA type 1 enclosure. Cover control offered consists of reset only; start, stop-reset, and three-position selector switch. Hp ratings are three-phase, 110 v, ¾ hp; 208/220 v, 1½ hp; 380/440/550 v, 2 hp—for single phase, 115 v, ½ hp; 230 v, 1 hp. Measures 5¼ x 7 x 4 4/16 in. Cutler-Hammer, 315 N 12th St, Milwaukee.

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## Miniature servo gearhead . . .

is for use in servomechanisms and other electromechanical systems that demand a high order of accuracy. Almost 1000 differ-

continued on page 104

# You get Cast Bronze Bearings with a Pedigree from Johnson Bronze

Bearings with a *pedigree*—rigidly controlled quality from ingot to mold to finished part—that's what you get when you buy cast bronze bearings from Johnson Bronze Co.

Johnson's 59-year record of consistently supplying *pedigreed* bearings has built a reputation for being "accepted on sight." Close alloy and dimensional control make your inspection easy. The *pedigree* of these bearings tells you why.

So why not put more quality into your product with Johnson cast bronze bearings? Call, write or wire Johnson Bronze. Put the *pedigreed* bearings to work for you.

## Johnson Bronze Company

New Castle, Pa.

West Coast Plant: Oakland 8, Calif.



CIRCLE 103 ON READER SERVICE CARD 103

ent ratios are available from 3.08:1 to 16,384:1. Ratios are obtained by using from two to seven gear stages and a motor output pinion with either 10, 12, 13 or 15 teeth. Gearhead is primarily for mounting to standard size 11 motor. Incorporates integral output spur and output shaft, with output shaft fully supported between bearings. Output torque is 25 in.-oz continuous and starting torque is 0.015 in.-oz max. Backlash through gear train is less than 45 min. for two-stage unit and less than 30 min. for all other units. Max weight is 3.820 oz. **Exact Engineering and Mfg Co, Oceanside, Calif.**

**Circle 323 on Reader Service Card**

## Miniature in-line check valve

is for applications too small to accommodate larger check valves and butterfly valves. Available in sizes from 0.25 to 0.50 in., in-line check valves are for direct coupling into high-pressure, high-temperature, airflow lines. Valve allows air to flow in one direction only and closes immediately upon airflow reversal. Max temperature is 900 F with max internal leakage of 0.04 lb/min at 300 psi. External leakage is zero. Weight is 0.12 lb for 0.25-in. valve. **Barber-Colman Co, Rockford, Ill.**

**Circle 324 on Reader Service Card**

## Pressure-sensitive foam plastic

made of polyurethane is available in 30-ft rolls, ¼-in. thick and in a variety of tape widths. Applies to clean, dry surfaces by removing vinyl plastic liner exposing pressure-sensitive adhesive. Tapes are said to be fungus- and mildew-proof, chemically inert and to withstand temperatures up to 248 F. Samples are available. **United Mineral & Chemical Corp, 16 Hudson St, New York 13.**

**Circle 325 on Reader Service Card**

## Three 2-part epoxy adhesives . . .

cure at room temperature under contact pressure. The three structural adhesives

continued on page 106

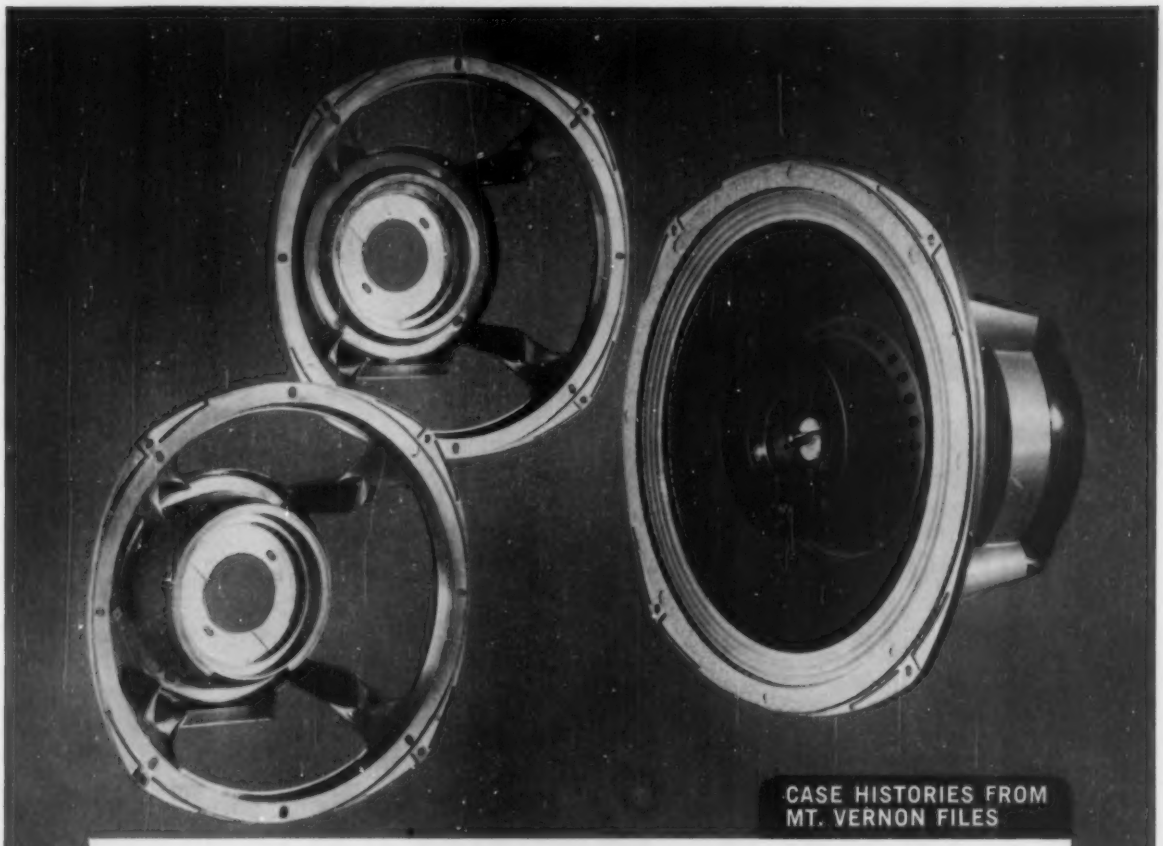
VERSATILE...
LOW
COMPRESSION
SET
NEOPRENE

TECHNICAL MEMO ON LINEAR COMPOUNDS
7354-70 and 7309-85
—outstanding for O-rings; adaptable to U-cups, V-rings and other sealing designs.
• Neoprene with low compression set properties
• High resistance to wear
• Low gas permeability—advantageous for use in oxygen, carbon dioxide and gaseous fuels
• Effective sealing from −40°F to +225°F

FLUIDS COMPATIBLE WITH THESE COMPOUNDS
Acetic Anhydride • Acetonitrile • Amyl Alcohol • 1-Butene • Butter • Butyl Alcohol • Butyric Acid • Castor Oil • Diacetone Alcohol • Ethyl Alcohol • Ethylene Glycol • Ferric Chloride • Fluorolube GR-362 • Fluorolube GR-544 • Freon 12 • Freon 13 • Freon 22 • Freon 114 • Freon 115 • Formaldehyde • Furfuryl Alcohol • Glycerine • Hydrochloric Acid (dilute) • Isopropyl Alcohol • Larex • Lard • Methyl Alcohol • Methyl Cellosolve • Milk • MIL-L-17331 • Mobil Nyvac #20 • Nitric Acid (dilute) • Olive Oil • Pinene • Sea Water • Sulfuric Acid (dilute) • Tellus #33 • Triethanolamine • Tung Oil • Ucon Lubricants • Wagner Brake Fluid

*For complete technical data—including list of incompatible fluids—request Bulletin 56707-1. Linear, Inc., State Road and Levick St., Philadelphia 35, Pa.*

PERFECTION IN RUBBER
LINEAR
LINEAR, Inc. STATE ROAD & LEVICK ST. PHILA 35, PA.



CASE HISTORIES FROM
MT. VERNON FILES

# From 1 Mt. Vernon Die...
# 2 Castings...7 University Speakers

This University* Loud Speaker basket won first prize in the New Jersey Zinc Company "Lighter Than You Think" Die Casting Contest. It is one of two castings used to produce all seven new University wide range Series 200 speakers.

The basket weighs only 2 lbs. 12 ozs; measures 13" across corners; is 4⅝" deep and has a minimum wall thickness of .040". It is a one-piece, non-magnetic zinc casting that provides perfect rigidity for the entire structure assuring life-long stability and reliability. Furthermore, its narrow struts offer a minimum of reflecting surfaces, thus avoiding unwanted peaks and valleys in the frequency response of the speakers.

University engineers, thoroughly familiar with inherent advantages of die casting, design for maximum effectiveness of the art. The result ... an ingenious Mt. Vernon die with *interchangeable cores enabling them to cast two modified baskets from one die*. And because they have been working with Mt. Vernon for many many years, they dare to try the unconventional approach knowing full well that they can always depend on Mt. Vernon to follow through.

You may not be trying to win prizes ... just aiming for lower production costs. In that case we can show you how it can be done with die castings. Just call your nearest M.V. Sales Representative for quick action.

*University Loudspeakers, Inc., White Plains, N.Y.

**MT. VERNON DIE CASTING CORPORATION**
STAMFORD, CONNECTICUT

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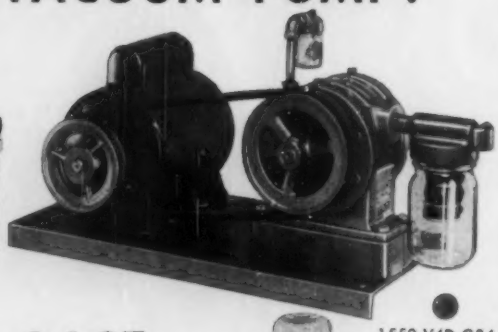
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

Basic 1550

# Need an original equipment VACUUM PUMP?

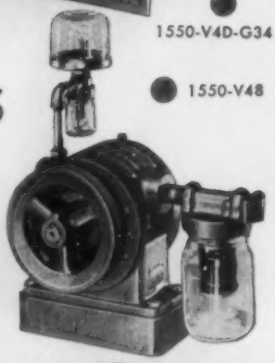
GAST ROTARY AIR PRODUCTS

1550-V16A



1550-V4D-G34

## SEE HOW GAST CUTS YOUR COSTS



1550-V48

These pictures demonstrate how *your* product —and cost budget—may benefit when you select Gast rotary Vacuum Pumps for original equipment.

Above (1) is a basic Model 1550 less accessories (one of 13 sizes). For current, active customers, Gast builds this model in dozens of variations. Each one meets specific needs for vacuum, pressure, lubrication, drive method and type of service.

For example, (2) is equipped with wick oiler, and intake and outlet filters for both vacuum and pressure used on paper feeding applications. (3) includes fan-pulley, belt, motor and base as sold for intermittent operation on vacuum-back cameras, vacuum chucks and plastic sheet forming units. (4) has new, large constant-level oiler for rigorous industrial duty. (5) *never* needs oil—has carbon vanes for oil-free air. (6) is a 1550 Model Air Compressor with air intake filter.

As you see, each original equipment buyer gets a job engineered pump. *In the same way, you can save money, because Gast ingenuity—and tooling and manufacturing efficiency—permit precision quality at production prices.*

1550-V105

1550-P41A
Air Compressor

WRITE FOR FULL DETAILS—REQUEST CATALOG

GAST MANUFACTURING CORP., P.O. Box 117-P Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE OR FLUID POWER DIRECTORY

GAST ROTARY

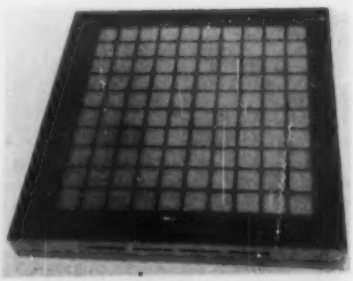
- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

*"Air may be your answer!"*




are used for high-strength metal and plastic structural bonding where heat and/or pressure are not feasible in the bonding operation. All three adhesives maintain high-strength properties over service temperatures of —67 to 160 F. Shear strengths of metal-to-metal assemblies bonded with these adhesives range from 2300 to 3200 psi at 75 F. Reported to have high creep resistance under constant stress, exceptional adhesion to metals and plastics, and good resistance to water, hydraulic oil and aromatic fuels. **Adhesives, Coatings and Sealers Div, Minnesota Mining and Mfg Co, 900 Bush Ave, St Paul 6.**

**Circle 326 on Reader Service Card**



**Annunciator lamp cabinet . . .** offers up to 100 back-lighted windows, 3½ in. sq, which can carry either engraved messages or hand-marked legends applied with grease pencil. Windows can be supplied in sizes larger or smaller and can be grouped as desired in flush-or surface-type cabinets. All lamp sockets are wired to a common terminal block, which is offered for 24-, 115-, or 220-v service. Units are also available with individual pushbuttons and/or toggle switches. **H R Kirkland Co, 8 King St, Morristown, NJ.**

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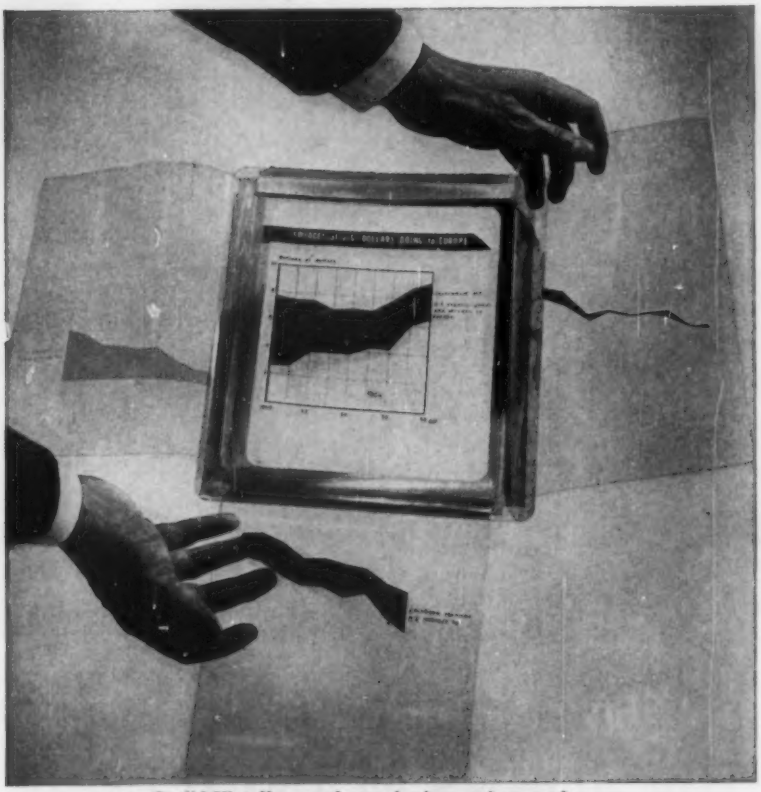
# OZALID NEWSLETTER

*NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING*



Ozalid Viewfilms produce color images in seconds . . . and at lower cost than conventional methods.

## Need low-cost color in a hurry?

Four-color, three-color, or even two-color for that matter . . . no problem; Ozalid's Viewfilms provide the perfect low-cost answer.

Suppose we want to produce a performance chart in which each factor is a different color.

It's a snap. Just take translucent paper and draw the desired curve or dotted line (as the case may be) on the sheet.

Next, run the master through your Ozalid machine together with an Ozalid Viewfilm of the proper color. Want to add more material in a different color? Just prepare another master, select a different colored film, and run them as you did the first pair. When you're all through, overlay the films in sequence and tape them into register. Your result is a composite color chart that's very dramatic . . . very convincing!

This is just one illustration to start your mental salivary glands working. We are sure that you can find uses we haven't even dreamed of, once you get going. And if you discover any new applications for this best of all possible color worlds, tell us about them so we can spread the good news to others.

### When it comes to cost estimating . . .

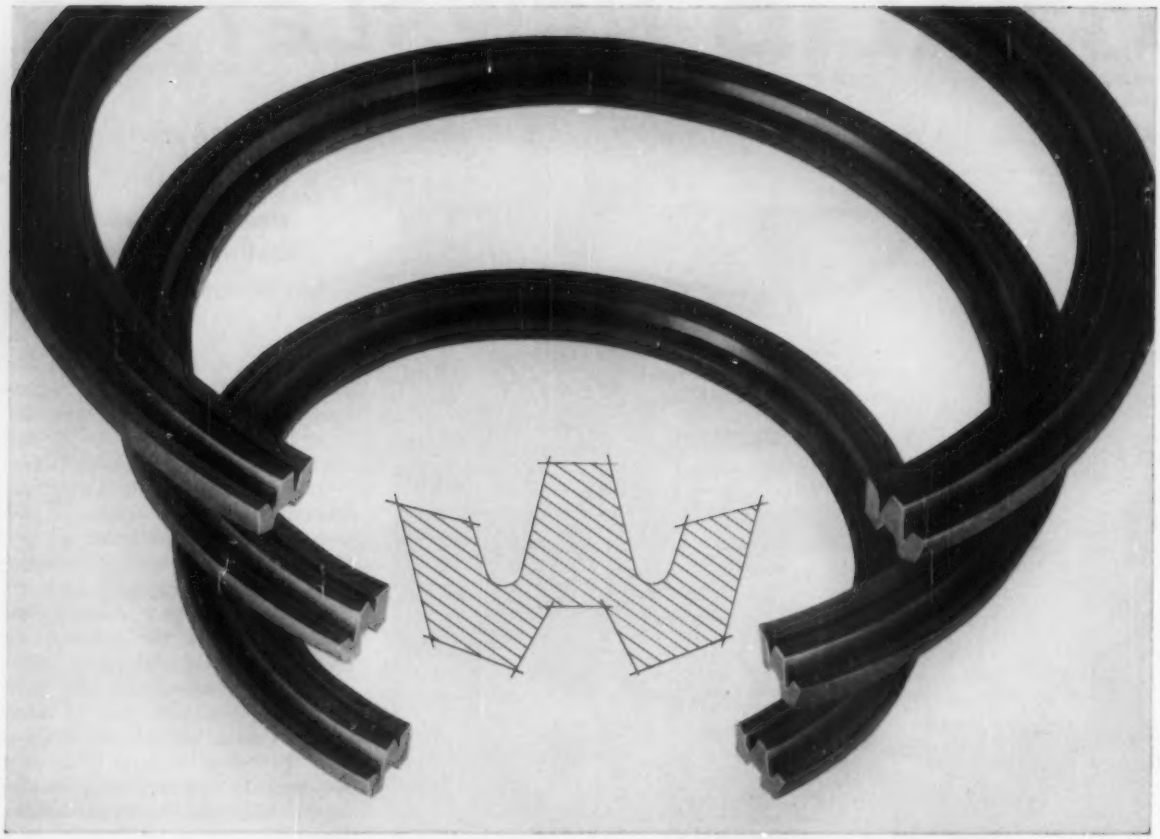
. . . there's nothing like a handy whiteprinter to cut preparation time of cost estimates, according to the Stackpole Carbon Company, St. Mary's, Pa. The company's Supervisor of Cost Estimating has just written us a letter on the subject which we pass on to you verbatim. "Our estimates are made in pencil on printed translucent vellum in pad form. These are reproduced on specially cut and punched Ozalid copy paper. Originals carry only basic information that has to remain constant. And from the originals we produce duplicate originals on Ozalid sepia line intermediate paper (#402 IT) as required, and these are used until the basic information is obsolete. To revise a cost, it is only necessary to add current rates and extend. With this simple Ozalid method we have eliminated typing, proofreading, and copying errors."

The Supervisor goes on to say that Stackpole uses Ozalid copying in many other areas of its business because of convenience and economy. Perhaps we'll be able to tell you about these uses in a future *Newsletter*.

### Here's what 100 usable feet per minute can do for you

Speed up your production? Of course! But that's only the beginning. Look at it this way. One Printmaster 1000® working at a usable 100 feet per minute matches the output of several smaller, slower machines *but takes up less valuable floor space while handling widths up to 54 inches!* You save on production time and costs due to higher working speeds! And the Printmaster 1000 is probably the toughest, most durable unit ever produced. This means even greater savings in downtime and service charges. Our first recommendation for any shop having heavy work loads is this 100-foot champ . . . the Printmaster 1000.

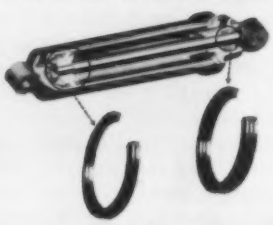
***Ozalid***—*Division of General Aniline & Film Corp.* • *In Canada: Hughes-Owens Co., Ltd., Montreal*



# Efficient sealing made to your measure... by JOHNS-MANVILLE

For equipment that requires other than standard packing styles, dimensions or materials . . . J-M offers made-to-your-measure custom moulded packings.

**3-YEAR PERFORMANCE TESTS PROVE LONG LIFE AND EFFICIENCY OF J-M UNEEPAC**



*For 3 years, a J-M customer gave Uneepac "the works." Uneepac Rod Packings got a 350,000-cycle test; Uneepac Piston Rings a 150,000-cycle test. Both provided a perfect seal for 3 years . . . proved able to stand working pressures to 2,500 psi and shock pressures to 4,000 psi!*

These packings are exactly engineered to measure up to your service conditions. J-M will select the materials that most economically handle temperature or other conditions. J-M will also recommend the specific design and construction needed, taking into account pressures . . . motions . . . and all other factors found within the equipment.

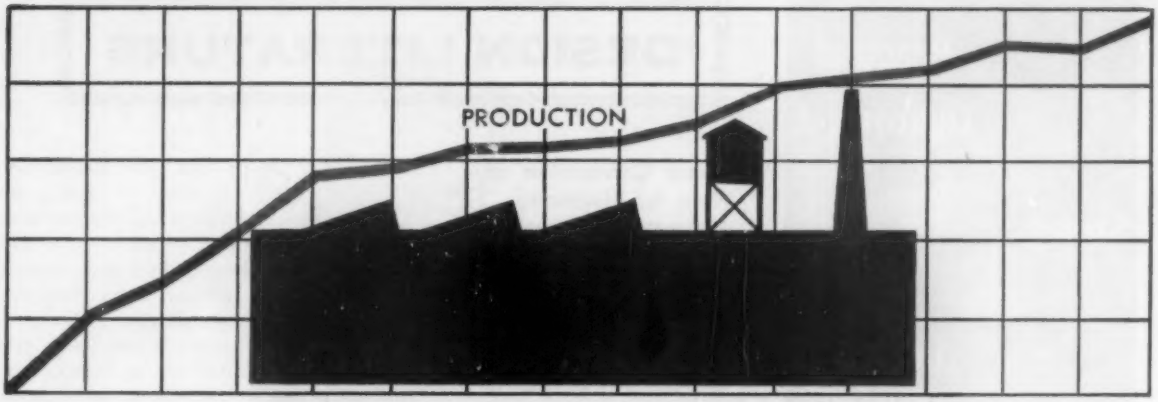
More and more manufacturers and those concerned with preventive maintenance now specify from J-M's broad selection of standard moulded automatic packings . . . or call on J-M's custom service. Either packing, whether standard or custom-made, is designed to give you optimum economy per packings dollar.

Here are some of the reasons why. Each pressure-actuated ring is an efficient, individual seal, interlocks with adjacent rings without compression adjustment. J-M packings are quick and easy to install. They are self-centering . . . self-adjusting . . . and offer interesting design possibilities. With J-M UNEEPAC®, for example, you can design smaller piston and rod stuffing boxes, and still get efficient sealing even in minimum packing depth.

Immediate shipment of all standard J-M packings. And complete information on J-M's entire line . . . plus specific recommendations for various applications and service conditions . . . is in free booklets PK-126 A and PK-148 A. See your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS




# How to expand without added expenditure

Right away let's make this point clear: you won't find any magic formula here for expanding your plant physically at no cost. What you *will* find are facts about a material that can definitely help expand your plant's productivity . . . and your product's salability.

That material is Masland Duran Clad, the new semi-rigid vinyl for laminating to metal sheets or coils according to your specifications . . . the built-in finish that obsoletes dipping, spraying, brushing, coating and similar finishing methods . . . the vinyl-to-metal laminate that can even do away with the need for having a finishing department.

Think what this can mean in terms of expanded productivity. Space now devoted to finishing operations can be used to expand your production area. Money currently spent in equipment, maintenance and finishing supplies can be channeled to more productive use. Costs of rejects, and the insurance costs of handling explosive materials can be eliminated, too, since Clad enables you to work with *prefinished* parts.

Consider, too, what Clad can mean in greater sales potential for your product. This durable, decorative vinyl can be produced in easy-to-clean colors . . . and in plain, textured or embossed designs. And here's the beauty of Clad from a production standpoint: It can be cut, crimped, drilled and even deep-drawn, without affecting color or design . . . without distorting the material itself . . . and without the need for any special processing equipment or methods.

Truly, Masland Duran Clad merits your most serious consideration right now . . . for, make no mistake about this: *vinyl-to-metal laminates are here to stay and grow.* With production soaring from one million square feet to 18 million in just three years . . . and from 115 to 150 million square feet estimated for 1960 . . . they are obviously lowering finishing costs and increasing design flexibility in a big way.

To safeguard and improve *your* competitive position, you will find it well worthwhile to mail this coupon for more information on Masland Duran Clad . . . and the laminators serving your area.

***Industrial Products Division***

**THE MASLAND DURALEATHER COMPANY, Dept. PE, Philadelphia 34, Pa.**

Masland Duran
CLAD
vinyl finish

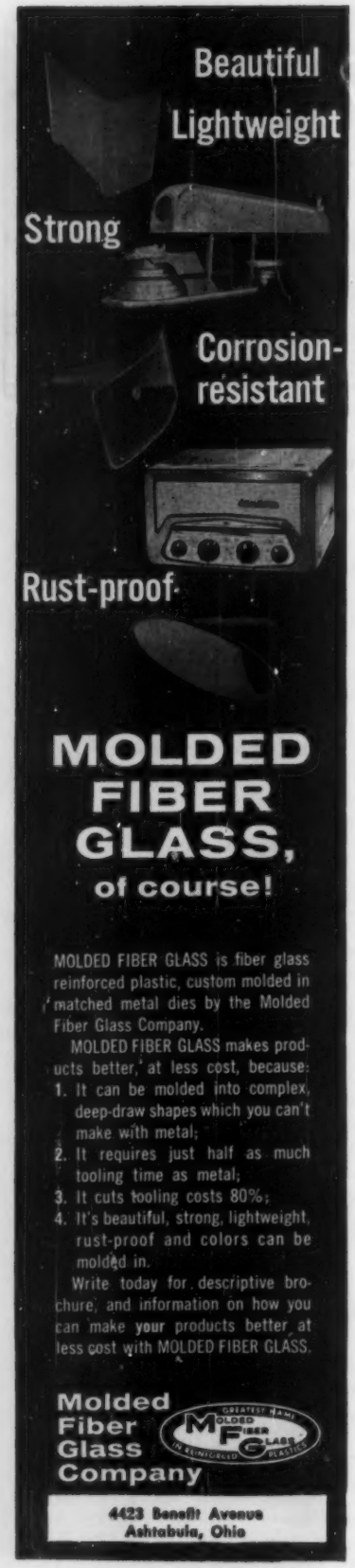
THE MASLAND DURALEATHER CO., Dept. PE
Amber & Willard Sts., Philadelphia 34, Pa.
*Please send information and samples of Clad*

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____


Beautiful
Lightweight
Strong
Corrosion-
resistant
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GLASS,
of course!
MOLDED FIBER GLASS is fiber glass reinforced plastic, custom molded in matched metal dies by the Molded Fiber Glass Company.
MOLDED FIBER GLASS makes products better, at less cost, because:
1. It can be molded into complex, deep-draw shapes which you can't make with metal;
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Write today for descriptive brochure, and information on how you can make your products better at less cost with MOLDED FIBER GLASS.
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# DESIGN LITERATURE

## Direct Conversion of Heat to Electricity

*JOSEPH KAYE and JOHN A WELSH. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9, approx. 325 pp. $8.75.*

Man's dream of devising a box with no moving parts, which converts thermal energy directly into electrical energy, has become a reality in the laboratory. It promises to become an industrial reality in a few years. But this field of direct conversion is so new that no trained or experienced personnel exist, and there has been no single or concentrated source of reference material. This volume—a pioneer effort—is an edited assortment of technical papers written originally for an MIT summer meeting by principal persons in the new technology of direct conversion. It includes fundamental discussions in thermoelectric-energy conversion (the thermocouple), thermionic-energy conversion (the vacuum tube and the gaseous tube), magnetohydrodynamic conversion (separating the positive and negative charges in a gas), and fuel cells (the separation of positive and negative charges during a chemical reaction). The contributors offer considerations of the practical applications and problems associated with each type of conversion scheme.

## Stress Concentrations and Cyclic Loading

*American Society for Testing Materials, 1916 Race St, Philadelphia 3. 8½ x 11, 108 pp, $4.50.*

To determine the state of knowledge in the field of stress concentrations and cyclic loading at elevated temperatures, the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals sponsored a two-part project designed to survey the published literature in this area. The result is this publication (full title: "Literature Survey on Influence of Stress Concentrations at Elevated Temperatures and the Effect of Nonsteady Load and Temperature Conditions on the Creep of Metals–STP-Z60") which brings into focus in a comprehensive fashion the tremendous amount of information available on these subjects.

The first survey, covering the effects of nonsteady load and temperature conditions on creep of metals, describes the fundamental investigations, summarizes data on alloys under complex variations of load and temperature, and reviews several analytical procedures for calculating nonsteady behavior from steady-state stress tests.

The second survey, on stress concentrations, reviews the available notch-rupture data with the idea of establishing fundamental influences of stress concentrations, testing variables, and the influence of alloy compositions. Also included is a section dealing with the application of notch data to the problem of component design.

## Evaluation of Electrical-discharge Machining

*PB-161267 (Report No. 59-1516). Office of Technical Services, Dept of Commerce, Washington 25, DC. 9 x 11, 30 pp. $1.*

This early report surveys machining capabilities of a modified Cincinnati vertical milling machine with electrical discharge current from an Elox power supply. Report is outdated by the rapid developments in the electromachining field. The new machines offer higher cutting speeds, better surface finishes, along with better dimensional accuracy (see *PE—Mar 2 '59, p 50*). Another recent development claims it can remove metal by electromachining without tool wear.

Although old, many of the basics given in this early report still apply.

# ABSTRACTS FROM THE LITERATURE

## Machining Glass-plastics

Practical production methods for glass-plastics laminates are described and assessed for their utility.

*"Techniques for Machining Glass-plastics Laminates," E. C. Graesser, National Vulcanized Fibre Co, Wilmington, Del. Plastics Technology, Nov '59, 630 Third Ave, New York 17.*

## Design of Forgings

Presents basic principles and shows how designer can apply them most satisfactorily. A table of drop-forging

continued on page 112

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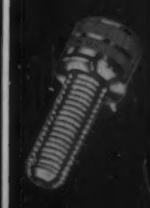

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thickness, surface and offset tolerances is included along with 8 illustrated examples of principles.

*"Design Principles of Forgings," R. C. Jones, Head Wrightson Stampings Ltd. Engineering Materials and Design, March '60, Drury House, Russell St, London, WC 2, England.*

### Tadpole Seals

Describes various components used in the manufacture of tadpole seals, which are usually composed of a body or bulb and a tail. They are mainly used as static seals. In general they seal against air or gases under low pressure differential. Their chief function is to prevent the passage of low-pressure gases or to seal against the passage of dust, dirt, or flame. They may be made from one material, such as an elastromer extrusion, or they can be made from many different components. These seals may vary in size and shape. They can be endless, circular, or conceivably any shape within the limitations of manufacture. Tail is used to hold the bulb in position. The bulb accomplishes the seal.

*"Tadpole Seals: Components, Design, and Use," R. H. Holmes, General Asbestos and Rubber Division, Raybestos-Manhattan Inc. Society of Aircraft Materials and Process Engineers, PO Box 39632, Griffith Sta, Los Angeles 39.*

## CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 118.

AIR-TUBE CLUTCHES AND BRAKES—Catalog, 32 pp. Contains specifications, application information and suggested clutch and brake arrangements. Wichita Clutch Co, Wichita Falls, Tex.

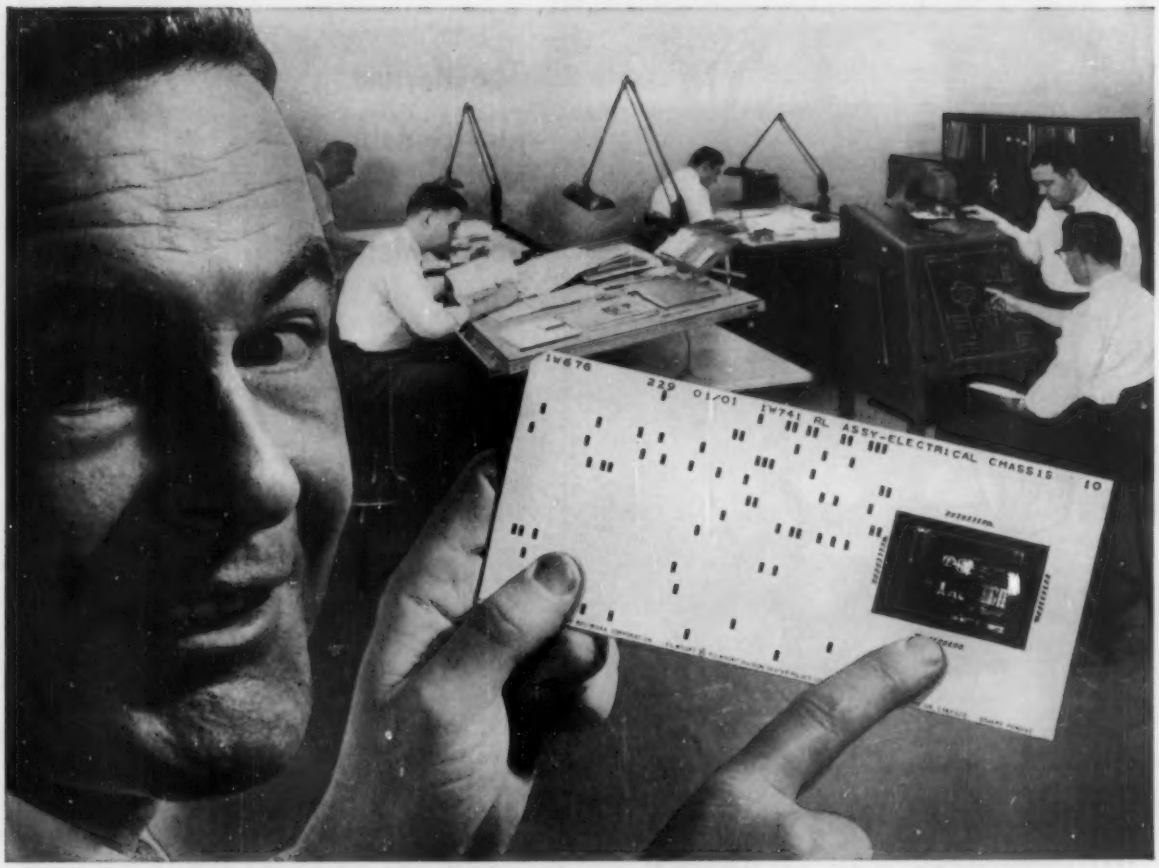
**Circle 350 on Reader Service Card**

HIGH-TEMPERATURE WIRE AND CABLE—Catalog, about 56 pp. Discusses high-temperature wire and cable and presents specifications and sizes for various plastic-insulated wires and cables. Tensolite Insulated Wire Co Inc, W Main St, Tarrytown, NY.

**Circle 351 on Reader Service Card**

ALUMINUM PRODUCTS—Bulletin 30-1, 20 pp. Information on aluminum coil, sheet, plate, tubing, pipe, rod and bar available from stock with guide to selection. Covers Federal specifications, analyses, mechanical properties, tolerances, machinability ratings, finishes, corrosion

continued on page 115

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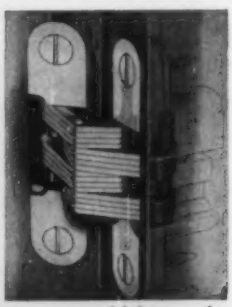

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resistance and relative costs of aluminum alloys. Jos T Ryerson & Son Inc, Box 8000-A, Chicago 80.

**Circle 352 on Reader Service Card**

ELECTRONIC HARDWARE – Catalog 32, 32 pp. Includes more than 380 standard electronic terminals and hardware. With specifications and ordering information. Lerco Electronics Inc, 501 S Varney St, Burbank, Calif.

**Circle 353 on Reader Service Card**

MAGNETIC-PARTICLE CLUTCHES–Brochure, 16 pp. Describes characteristics of line of magnetic-particle clutches with capacities from 2.5 in.-oz to 1900 in.-lb. Includes curves, installation drawings and other illustrations. Lear Inc, Box 688, 110 Ionia Ave NW, Grand Rapids, Mich.

**Circle 354 on Reader Service Card**

SCREW CONVEYOR-DRIVES – Bulletin 7106, 20 pp. Design features and accessories of screw-conveyor drives for applications of ½ to 30 hp in four ratios are described. Includes selection and dimensional information, NEMA motor dimensions and nominal sheave ratios for typical unit ratios and conveyor speeds. Falk Corp, Dept 255, Box 492, Milwaukee 1.

**Circle 355 on Reader Service Card**

METAL-FORMING PROCESS–Bulletin 500-P4, 8 pp. Explains method whereby cold metal is pressure-shaped into desired thicknesses and circular shapes. Covers machine, various shapes, range of sizes, types of finishes and suitable metals and alloys. Representative samples of formed components are shown. Commercial Shearing & Stamping Co, 1775 Logan Ave, Youngstown 1, Ohio.

**Circle 356 on Reader Service Card**

SOCKET-CAP SCREWS–Bulletin 773, 8 pp. Specifications for 1960 series socket-cap screws. Tables present dimensions, concentricity limits and threading dimensions. Compares dimensions of 1960 series and 1936 series screws. Bristol Co, Waterbury 20, Conn.

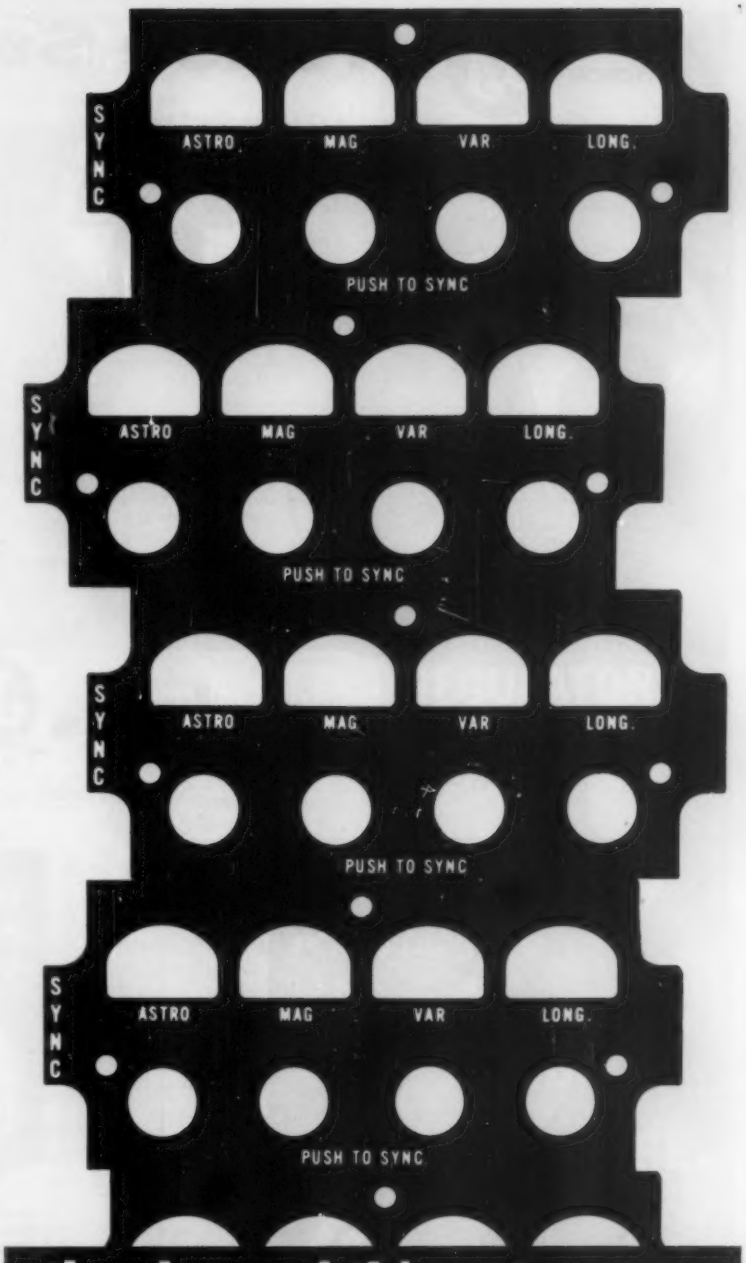
**Circle 357 on Reader Service Card**

ELECTRONIC TIMING DEVICES AND CONTROLS–Bulletin 5907, 6 pp. Short-form catalog describes typical electronic timing devices and controls. With specifications and typical timing diagrams. Tempo Instrument Inc, Hicksville, NY.

**Circle 358 on Reader Service Card**

ELECTRIC CLUTCHES AND BRAKES –Brochure, 6 pp. Lists sizes, rated static torque and coil power watts of more than 20 types of fixed field, miniature, small and larger electric clutches and brakes. With diagrams. A conversion

continued on page 117

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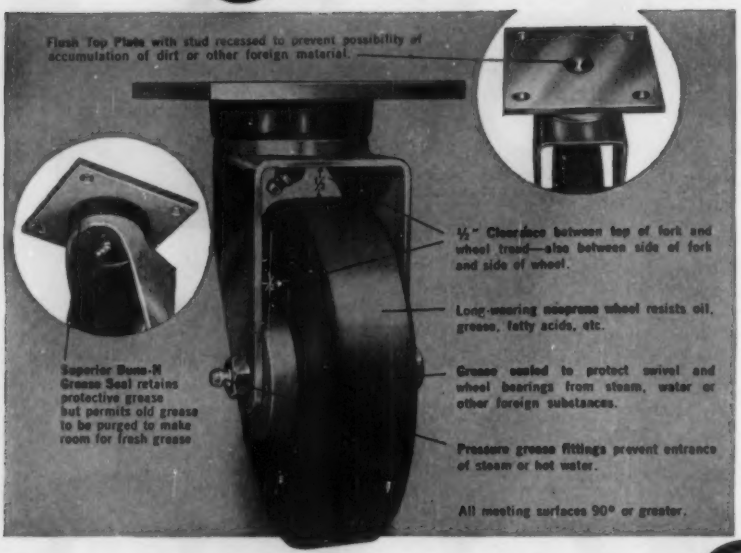
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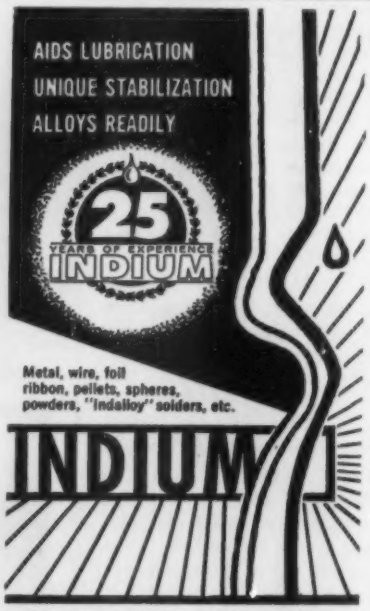


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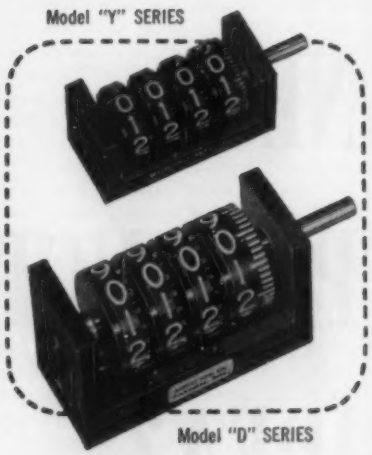

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**DESIGN LITERATURE** . . . . . continued

table and clutch brake selection section are provided. Simplatrol Products Corp, 24 Salisbury St, Worcester, Mass.

**Circle 359 on Reader Service Card**

SHEATHED AND INSULATED THERMOCOUPLES—Bulletin P1281A, 6 pp. Describes construction and typical applications. Table presents specifications. Bristol Co, Waterbury 20, Conn.

**Circle 360 on Reader Service Card**

MECHANICAL SEALS—Bulletin AD-150, 8 pp. Covers engineering and application of seals. Illustrated with sectional and dimensional drawings. Outlines temperature, pressure, shaft speed and operating information. Garlock Inc, 446 Main St, Palmyra, NY.

**Circle 361 on Reader Service Card**

ADHESIVES—Bulletin, 4 pp. Principal uses and characteristics of representative formulations in line are presented in table form. Section describes solvent-base, water-base and hot-melt adhesives. Bostik Adhesives, BB Chemical Co, 784 Memorial Dr, Cambridge, Mass.

**Circle 362 on Reader Service Card**

CUP PACKINGS—Bulletin, 4 pp. Describes properties and characteristics of cup packing, standard sizes and performance information. E F Houghton & Co, 303 W Lehigh Ave, Philadelphia 33.

**Circle 363 on Reader Service Card**

MINIATURE-FAN AND BLOWER SELECTOR—Bulletin FB, 4 pp. Guide to determining cooling requirements for electronic applications and for selecting proper type and capacity of miniature fans and blowers. Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.

**Circle 364 on Reader Service Card**

STEEL-SPRING MACHINERY MOUNTS—Bulletin K3C, 6 pp. Series of eight typical case histories, with installation photos, describe how spring machinery mounts solved representative range of vibration problems. Korfund Co Inc, 48-19G 32nd Pl, Long Island City 1, NY.

**Circle 365 on Reader Service Card**

CONTINUOUS - READING METER-RELAY—Bulletin S-2-1, 4 pp. Presents descriptions, specifications and prices of meter-relay in three case styles. Features diagrams showing how various circuit components are affected during operation of continuous-reading meter-relays. Assembly Products Inc, Chesterland, Ohio.

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THERMOSETTING LAMINATED MATERIALS—Engineering data chart, 4 pp. Shows principal grades and properties

continued on page 118


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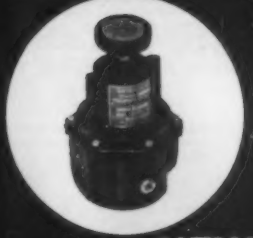

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**DESIGN LITERATURE**.....continued

of each, illustrated by representative component parts. Final page lists NEMA tolerances for laminated sheet materials in standard thicknesses. Comco Plastics Inc, 98-34 Jamaica Ave, Richmond Hill 18, NY.

**Circle 367 on Reader Service Card**

SINTERED BRONZE BEARINGS—Catalog 60-04, 4 pp. Tells how sintered bronze bearings have been designed to replace miniature precision ballbearings in some applications. Includes design features, available styles and sizes, specifications and applications. Northfield Precision Instrument Corp, 4400 Austin Blvd, Island Park, NY.

**Circle 368 on Reader Service Card**

THROTTLE VALVES—Bulletin 460, 4 pp. Illustrates and describes line of throttle valves for safe control of compressed air on pneumatic operating equipment. Hose Accessories Co, 2720 N 17th St, Philadelphia 32.

**Circle 369 on Reader Service Card**

ADJUSTABLE INDUSTRIAL PULSE SWITCH—Data sheet 173, 2 pp. Discusses features of adjustable industrial pulse switch and includes photos, dimensional drawings, characteristics and prices. Micro Switch, Freeport, Ill.

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ARC INHIBITORS—Bulletin 9600, 2 pp. Describes application and installation of arc inhibitors and includes electrical characteristics and dimensions. Square D Co, EC&M Div, 4500 Lee Rd, Cleveland 28.

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POROUS - ANODE CAPACITORS — Bulletin GEA-7008A, 4 pp. Gives specifications for line of porous-anode capacitors, as well as performance characteristics and curves. General Electric Co, Schenectady 5.

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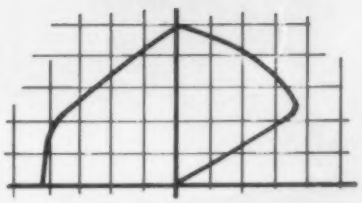

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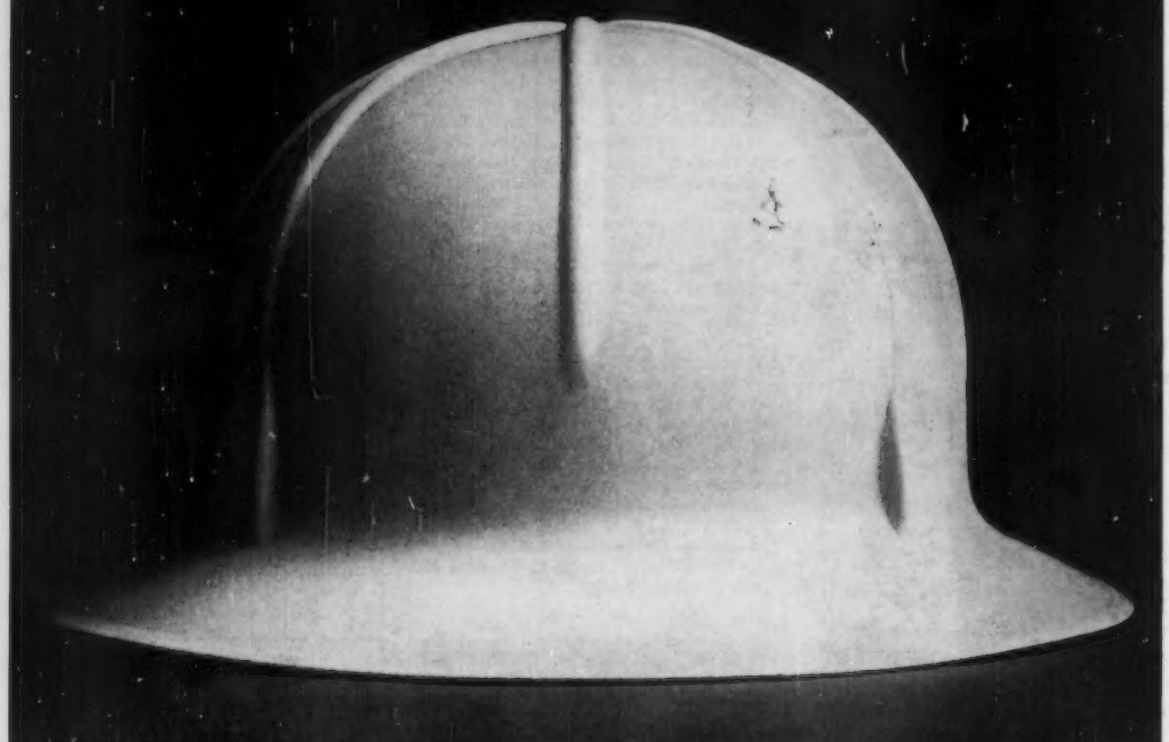

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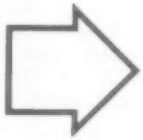

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| 14 | 34 | 54 | 74 | 94 | 114 | 134 | 154 | 174 | 194 | 214 | 234 | 254 | 274 | 294 | 314 | 329 | 344 | 359 | 374 | 389 |
| 15 | 35 | 55 | 75 | 95 | 115 | 135 | 155 | 175 | 195 | 215 | 235 | 255 | 275 | 295 | 315 | 330 | 345 | 360 | 375 | 390 |
| 16 | 36 | 56 | 76 | 96 | 116 | 136 | 156 | 176 | 196 | 216 | 236 | 256 | 276 | 296 | | | | | | |
| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

REPRINTS

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|---|---|---|---|---|---|---|---|---|---|
| P36 | P37 | P38 | P39 | P40 | P41 | P42 | P43 | P44 | P45 |
| P46 | P47 | P48 | P49 | P50 | P51 | P52 | P53 | P54 | P55 |

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### FABRICATION PROCESSES AND PRODUCTION

356—Metal Forming Process, 8 pp, Commercial Shearing & Stamping Co.

### POWER TRANSMISSION

350—Air-tube Clutches and Brakes, 32 pp, Wichita Clutch Co.

354—Magnetic-particle Clutches, 16 pp, Lear Inc.

355—Screw Conveyor-Drives, 20 pp, Fal Corp.

359—Electric Clutches and Brakes, 6 pp, Simplatrol Products Corp.

368—Sintered Bronze Bearings, 4 pp, Northfield Precision Instrument Corp.

### MECHANICAL PARTS

361—Mechanical Seals, 8 pp, Garlock Inc.

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 41 | 61 | 81 | 101 | 121 | 141 | 161 | 181 | 201 | 221 | 241 | 261 | 281 | 301 | 316 | 331 | 346 | 361 | 376 |
| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
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| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

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Company .....

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City ..... Zone ..... State .....

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 41 | 61 | 81 | 101 | 121 | 141 | 161 | 181 | 201 | 221 | 241 | 261 | 281 | 301 | 316 | 331 | 346 | 361 | 376 |
| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
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| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

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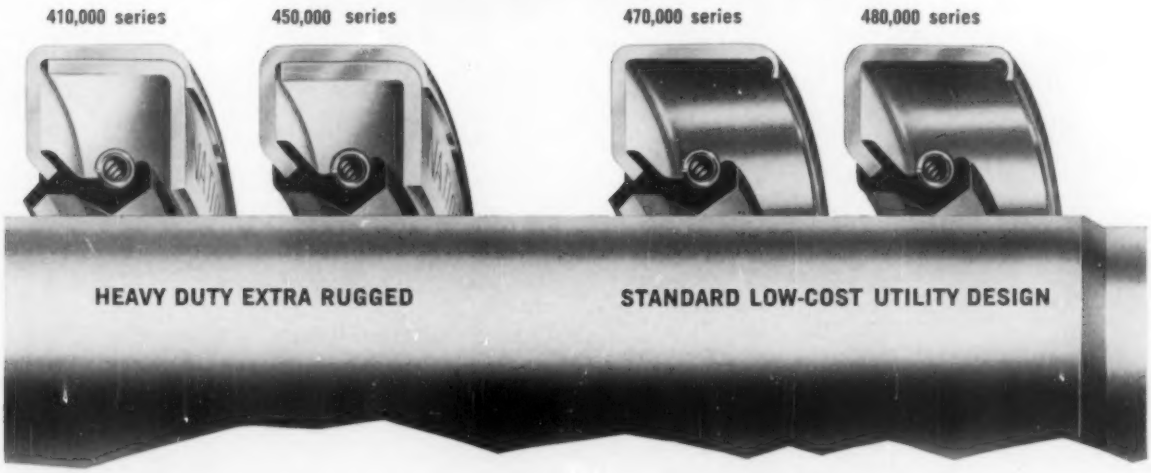


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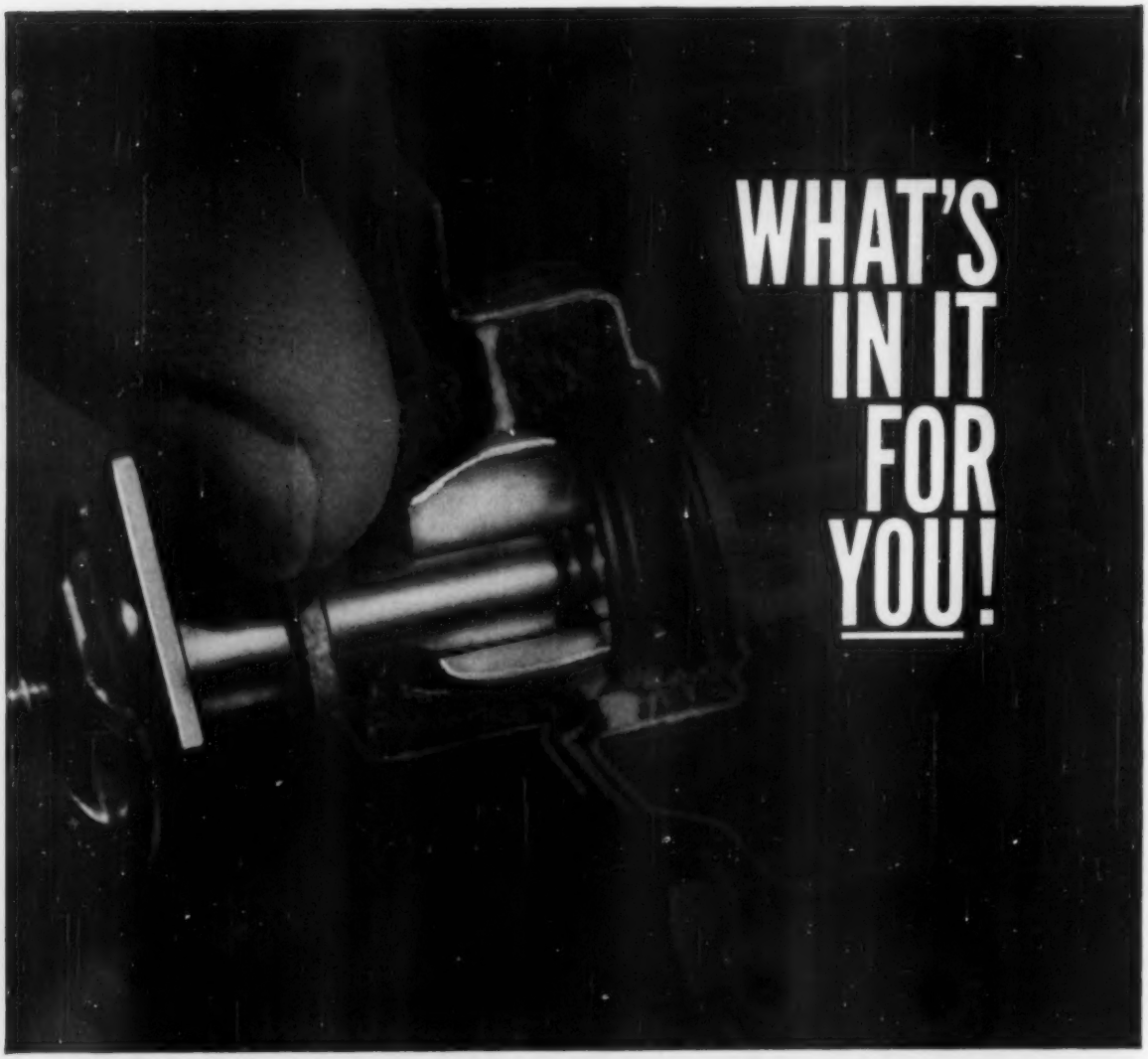


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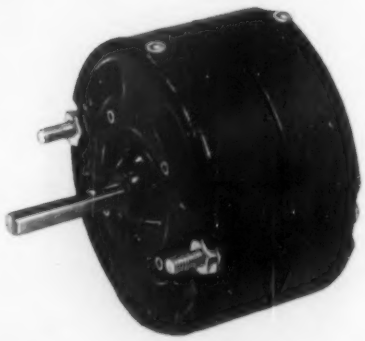

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